Member A.B.C.—A.B.P.

JUNE 1939 • THE *Petroleum* **Engineer** • VOLUME X NUMBER 9

Published by THE PETROLEUM ENGINEER PUBLISHING COMPANY . . Telephone 2-4571 . . Seventh Floor Allen Building . . DALLAS, TEXAS

A MAGAZINE OF METHODS FOR OPERATING MEN

CLARENCE MORRIS
President and General Manager

J. L. DWYER
Vice-President

W. T. BRYAN
Secretary-Treasurer

EDITORIAL

K. C. SCLATER
Vice-President and Editor

FRANK H. LOVE
Managing Editor

WALLACE A. SAWDON
Pacific Coast and Foreign Editor

H. LEE FLOOD
Associate Editor

ADVERTISING

W. L. LOVE
Vice-President and Advertising Manager

NEW YORK, N. Y.
ROGER MOTHERAL
6830 Burns Street
Forest Hills, Long Island,
Telephone: BOUlevard 8-2959

CLEVELAND, OHIO
AXE JONES
284 Bay View Road,
Bay Village, Ohio
Telephone: WEstlake 998-J

CHICAGO, ILLINOIS
E. V. PERKINS
1053 Pratt Blvd.
Telephone: SHEldrake 6571

TULSA, OKLAHOMA
T. J. CROWLEY
Vice-President
1402 South Owasso
Telephone: 3-4236

LOS ANGELES, CALIF.
R. C. WIPPERMAN
905¼ North Fairfax,
West Hollywood
Telephone: HEmpstead 1885

CIRCULATION—C. R. BARRETT, *Circulation Manager*

Contents

DRILLING AND PRODUCTION

The First Horizontal Oil Well 25
By LEO RANNEY

Application of Vacuum to Pumping Wells 31
By WALLACE A. SAWDON

Production Methods in the Rodessa Field (Part 2. Concluded) 35
By T. H. GIBBS

Recent Improvements in Technique of Aerial Photography (Part 2. Concluded) 141
By HERBERT THAYER BRUCE

A Comparison of Rotary, Beam, and Pneumatic Counterbalances (Part 2. Concluded) 144
By KENNETH N. MILLS

REFINING AND NATURAL GASOLINE MANUFACTURE

South Texas Recycling Plant Has 60,000,000 Cu. Ft. Capacity 33
By FRANK H. LOVE

Calculation of Transfer Area in Heat Exchangers (Part 1) 42
By JOHN GRISWOLD

Modern Gasoline Plant Operation Requires Well-Trained Personnel 150
By ROY W. MACHEN

OIL AND GAS TRANSPORTATION

A Field Balance for Weighing Pipe to Determine Rate of Corrosion 67
By T. H. MARSHALL *and* D. CHADS

GENERAL

A Decimal System for Classifying Data Pertaining to the Petroleum Industry (Part 6) 53
By LESTER C. UREN

Diesel Engine Performance Improved by Better Design 76
By ORVILLE ADAMS

PURCHASED ELECTRIC POWER SECTION

Estimating Power Requirements Twenty Years Ahead Hazardous 86
By E. A. ARMSTRONG

An Economic Study of Electric Power in Oil-Well and Pipe-Line Pumping Service 89
By W. H. STUEVE

Recent Developments in Electrical Equipment in the Petroleum Industry 100
By G. R. PROUT

Electric Power Plays Important Role in Water-Flooding of Nowata Field 109
By JERRY D. ROBERTSON

Analysis of Power Requirements in Refinery Operations 121
By W. H. STUEVE

Electric Power in East Texas and Rodessa Fields 131
By J. E. ELLIOTT

Purchased Electric Power in Oil Operations in Arkansas 135
By KENNETH C. JOHNSON

Southwest Texas Operators Recognize Value of Electric Power for Oil-Well Pumping 138
By NED W. BEAUDREAU

ENGINEERING NEWS OF INTEREST

Unusual Safety Record at a Louisiana Oil Refinery Discussed in U. S. Bureau of Mines Bulletin 146

Changes Announced in Methods of Publishing A.S.T.M. Standards 153

REGULAR DEPARTMENTS

The Course of Oil 12
Highlights in Oildom 14
Activities in Refining 17
Activities in the Oil Fields 18
Petroleum Statistics and Field Activities 20
Major Pipe Line Activities 22
The Petroleum Engineer's Continuous Tables (Installment No. 24) 51
Laugh With Barney 156
Running Tour With Men in the Industry ..... 159, 160, and 161
Machinery and Equipment ..... 162, 164, 166, 167, 168, 169, and 170
Trade Literature 177
Book Reviews 177
Meetings 179

Copyright, 1939, by The Petroleum Engineer Publishing Company

The Course of Oil

By K. C. SCLATER

Inequitable Proration Challenged It looks at the moment as though a change in the methods of allocating allowable production in the East Texas field were in the offing. It is likely, too, the change, if made, will involve acreage, consideration of which the Railroad Commission has heretofore avoided.

An injunction has just been obtained in Federal Court against the Railroad Commission restraining it from enforcing its proration orders with respect to the lease of the complainants in the East Texas field. The judge in the case ruled that the present method of allotting allowables in the field was unreasonable. It was his opinion that the difficulty in which the Commission finds itself is of its own making and grows largely out of its relaxation of its own spacing rules. "The drilling of thousands of wells, unnecessary so far as the public interest is concerned, has required them to listen to the demands of those well owners at the expense of other operators better situated. No effort has apparently been made to require those parties producing upon too densely drilled acreage to pool their tracts. There is no justification in law for taking complainant's property in order to recoup these parties who drilled these unnecessary wells."

Commenting further the judge said, "The duty enjoined on the Commission by the statute is to prevent waste. When in order to do that it has to limit production, then the statute says it shall allocate the allowable on a reasonable basis. Further than that it is without power to go. It is not its function to repay owners for wells drilled or to guarantee them a return. It can not enrich one man at the expense of another. It is obvious that this order as enforced does not apportion the allowable so far as complainant is concerned on a reasonable basis. If it does, then complainant might as well have had five of the poorest wells as five of the best. It might just as well have bought a one acre lease as twenty-five acres. It might just as well have bought on the edge of the field as in the center so long as its wells could make twenty barrels a day. The small surplus allotted on potential amounts to practically nothing and is so admitted by respondents own engineers."

In reviewing other cases the judge had noted, and emphasized the fact, that engineers of the Commission had frankly admitted that the present scheme of proration is nothing more or less than one on a per-well basis.

Significance is attached to the consideration the judge in this case has given to reservoir conditions in rendering his opinion. He comments that "it takes no account of the difference in the wells, of the richness or thickness of the sand, of the location upon the structure, of the porosity or permeability of the sand, of the estimated oil reserves, or of the acreage upon which the respective wells are situated. The worst property is raised to the level of the best and the best is lowered to the level of the worst.

"The disregard of acreage alone should be sufficient to condemn the plan. Here we have a case where a producer with a well to five acres can produce no more than his neighbor who adjoins him with a well on a fraction of an acre. Under the law in Texas, this oil in place belongs to the owner of the land or the leasehold. Any plan which contemplates that any party who can get enough ground to stick a drill bit down and obtain a well is entitled to produce as much as a party who owns ten times as much acreage adjoining him is manifestly wrong. The evidence shows that in a formation like the complainant's lease, one well can sufficiently drain ten acres. Therefore, there is no good reason why there should be fifteen or twenty wells drilled upon such a leasehold. Yet that is the result if complainant is to compete with a neighbor who drills a well on a fraction of an acre.

"It is manifest that other things being equal, the party with the largest acreage has the most oil. There is nothing in this order, however, that protects him in that ownership."

This opinion upholds what is considered to be sound modern practice, which takes into account reservoir conditions and oil in place. It clearly expresses no sympathy with "the law of capture." It takes cognizance of factual data on reservoir conditions and their consideration in determining allowables.

There is little reason to anticipate that chaos will result from this ruling, although it does have far-reaching implications. It throws doubt on the validity of the marginal well law. It may lead to a wholesale revision of the regulations now in force for allocating production in Texas. Although acreage is given some consideration in other fields of the state, as applied at present it is a compromise.

It is to be noted that in this case the validity of state proration statutes is not questioned. The complainants have no quarrel with the top allowable in the field or the well-spacing order (known as Rule 37). The complaint is against the method of administering and applying the proration order. It is declared to be unreasonable, discriminatory, and to constitute confiscation of the complainant's property. Although the injunction applies only to the complainant's lease, it may have reverberations for some time to come. Other operators in the field may seek similar relief from the court.

Whatever the outcome, this observation cannot be overlooked: methods of allocating allowables are undergoing a gradual change and the trend is unmistakably toward a fuller utilization of reservoir data as a basis for establishing equitable proration.

Finally, for a marginal well law to be effective and beyond attack, there should be strict adherence to well-spacing rules.

RESEARCH

How to make wire rope better.... How to use wire rope better... those are the two things about which Leschen research men are daily finding new facts.

That is why there is always a "HERCULES" **(Red-Strand)** Wire Rope to meet the new requirements of progressing industry. That is why "HERCULES" **(Red-Strand)** is always able to give you top-flight performance even on the toughest jobs.

Use "HERCULES" **(Red-Strand)** on your next job. It's made of acid open-hearth steel wire, correctly designed and manufactured according to advanced production methods to give you long, safe and economical performance.

"HERCULES" *Rotary lines are available in both Round Strand and Flattened Strand constructions —either Standard or Preformed.... We especially recommend the Preformed type of Wire Rope for Tubing Lines, Sucker Rod Lines and Winch Lines.*

STRENGTH
ELASTICITY
FLEXIBILITY
TOUGHNESS
DURABILITY

Benjamin Franklin's research in electro-physics, chemistry, medicine, meteorology and geology led him to new discoveries which greatly advanced civilization.

"HERCULES" RED STRAND WIRE ROPE — REG. U.S. PAT. OFF.

Domestic Distributors

AMERICAN SUPPLY CO., Kilgore, Texas

CASEY & NEWTON
901 Century Building, Pittsburgh, Pa.

GUSTIN-BACON MANUFACTURING CO.
Kansas City, Fort Worth, Houston, Tulsa

F. HAMILTON CO., Inc., Bradford, Pa.

HERCULES SUPPLY COMPANY
Fort Worth, Corpus Christi, Kilgore, Houston

HILLMAN KELLEY, Inc.
2441 Hunter Street, Los Angeles, Calif.

KIMBELL-BOSTIC SUPPLY CO., Inc.
Wichita Falls, Texas

THE B. LEVY ESTATE, Titusville, Pa.

MURRAY-BROOKS HARDWARE CO., Ltd.
Lake Charles, La.
Houma, Jennings, New Iberia, Villa Platte

NORTH TEXAS HARDWARE CO., Inc.
Vernon, Texas

NORVELL-WILDER SUPPLY COMPANY
Beaumont, Corpus Christi, Fort Worth
Houston, Monahans, Texas
Lake Charles, La.

PARKERSBURG SUPPLY COMPANY
Parkersburg, W. Va.

UNION PIPE AND SUPPLY CO., Inc.
Owensboro, Ky.

UNI[illegible] PIPE AND SUPPLY CORP.
Charleston, W. Va.

UNITED SUPPLY & MANUFACTURING CO.
Tulsa, Oklahoma City, Stonewall
Chase, Kan.; Hutchinson, Kan.; Houston, Tex.; Odessa, Tex.; Pampa, Tex.; Eunice, N. Mex.

WELL MACHINERY & SUPPLY CO., Inc.
Fort Worth, Texas

WESTERN MACHINERY CO.
Centralia, Ill.

Export Distributor

CONTINENTAL EMSCO COMPANY, Inc.
30 Rockefeller Plaza, New York, N. Y.
Branches: Buenos Aires, London, Ploesti

MADE ONLY BY

A. LESCHEN & SONS ROPE CO.

WIRE ROPE MAKERS — ESTABLISHED 1857

5909 KENNERLY AVENUE — ST. LOUIS, MISSOURI, U. S. A.

HERCULES (RED-STRAND) WIRE ROPE

NEW YORK	90 West Street	SAN FRANCISCO	520 Fourth Street
CHICAGO	810 W. Washington Blvd.	PORTLAND	914 N. W. 14th Avenue
DENVER	1554 Wazee Street	SEATTLE	3410 First Avenue South

« « HIGHLIGHTS IN OILDOM » »

New Proration Plan Adopted By California

The Central Proration Committee has adopted a new method of prorating California's crude oil production that is looked upon as being the most important step taken in years by the industry in that state. The plan was inaugurated June 1 and is designed to correct a condition of over-production that has existed for more than a year, and to attain a better balance between demand and production.

The formula provides for a graduated minimum allotment for each well in California, depending upon its depth, no well being allowed less than ten bbl. per day if capable of producing that volume. Moreover, no well, regardless of its depth, shall be assigned an allowable greater than 250 bbl. per day. The maximum heretofore has been 300 bbl.

The plan further provides that graduated curtailment, based upon well-depth and potential, shall be assigned to all wells not coming under the ten bbl. minimum or 250 bbl. maximum classification.

Minimum allotments based upon well-depth would provide for 11 bbl. per day from a well 2050 ft. deep, increasing to 50 bbl. per day for a well 6481 ft. deep, 75 bbl. for a well 8558 ft. deep, 100 bl. for a well 10,348 ft. deep, and a maximum of 142 bbl. for a well 12,954 ft. deep.

Should the potential production of a well be greater than the minimum allotment accruing to it on the basis of its depth, the remainder of the well's potential earns an allotment at a gradually diminishing rate.

●

Proposed Graduated Oil Tax Believed Constitutional

A proposed graduated production tax on crude oil, involving a maximum of 4 cents per bbl., has been held constitutional by Attorney General Gerald Mann of Texas in an opinion given in response to a request for a ruling concerning that section of an omnibus bill now under consideration by the state legislature.

The oil tax section of the bill would increase the existing levy of 2¾ cents per bbl., (or a percentage in that amount when the price of oil exceeds $1.00 per bbl.), to 4 cents per bbl. on oil from wells producing more than 20 bbl. per day, 3½ cents per bbl. on oil from wells producing 10 to 20 bbl. per day, 3 cents per bbl. on oil from wells producing five to ten bbl. per day, and 2¾ cents per bbl. on oil from wells producing less than five bbl. per day.

"The only possible constitutional question that we can see in the article submitted is whether the charging of this tax in different amounts per bbl., depending on the size of the well, is based on a reasonable classification," the opinion said. "We believe the courts would hold that this new act sets up a reasonable classification and that it is clearly valid and constitutional."

●

Crude Prices Up in Southern Oklahoma; Down in Illinois

Prices for crude oil have been increased 3 cents per bbl. in three southern Oklahoma counties by the Rock Island Oil Company. Officials of the company said improved conditions in the industry had prompted the increase. The counties affected are Carter, Stephens, and Garvin, and the top price for 40-deg. gravity or better crude will be $1.03 per bbl.

The Sohio Corporation, subsidiary of the Standard Oil Company of Ohio, has announced a reduction of 10 cents per bbl. on crude oil in the Illinois Basin area. The new price is $1.05 per bbl. A statement signed by J. F. Wilson, vice-president of the corporation, said the reduction was "made in view of the increase in the quantity of Illinois production which is being sold at cut prices ranging from 75 to 90 cents per bbl."

●

Question Finding of Helium In Germany

Recently an item was printed in *The Petroleum Engineer* concerning the finding of helium near the town of Bentheim, Germany, across the border from Holland. A reader who resides in Holland writes: "As I was rather surprised to find nothing about so important a matter in our newspapers, I made inquiry from those in position to know and obtained this reliable information: For some time wells have been drilled in Germany near the Dutch frontier with the object of striking oil. In January of this year, a small sulphur layer was struck. In this sulphur a *trace* of helium was detected. The amount of helium, however, is so small that the exploitation possibilities are nil."

●

Favor Extension Connally Act For Three Years

The Connally "hot oil" law will be extended for a period of three years if the recommendation of the Cole Subcommittee and the House Interstate and Foreign Commerce Committee is adopted. A bill passed the Senate some time ago making the act permanent. The Cole Subcommittee, however, after numerous hearings, made the recommendation that it be extended only for three years. This recommendation has been accepted by the House Interstate and Foreign Commerce Committee and it is believed the Senate will accept the change. The bill will go on the House calendar to be considered in the regular course of business. The act as now written expires June 30.

●

Asserts Illinois Needs No Proration Law

A special legislative committee has reported to the Illinois General Assembly that proration laws for the Illinois oil fields are not needed at the present time.

The recommendation was made following a comprehensive survey of the state's oil industry, and is based on the contention that there is no overproduction of oil at present and "no prospect of such in the near future." Regulatory measures, the report stated, would act as a definite deterrent to the establishment of refineries in the state's oil fields. All witnesses appearing before the committee were opposed to the imposition of any tax that would include undeveloped leases because such a tax would be inequitable and would retard the growth of the industry, the report stated further.

●

Michigan's Entry Strengthens Importance of Interstate Oil Compact

Increased attention is attracted to the growing power of the oil compact between oil-producing states by Michigan's recent entry into the group. Officials of the compact have as their goal a membership that will include all the more important oil-producing states. The 11 states—Arkansas, California, Colorado, Illinois, Kansas, Kentucky, Louisiana, Michigan, New Mexico, Oklahoma, and Texas—represent 93 percent of the nation's total oil production. The membership roll may be strengthened soon if the Governors of Arkansas and Louisiana decide to join the compact by executive order. California's entry hinges upon the outcome of a conservation bill now pending before the state legislature.

Activities in Refining

Percent Refining Capacity Operated

Western Division, 75.5 Percent **Central Division, 84.0 Percent** **Eastern Division, 87.1 Percent**

THE new combination delayed coking and cracking plant being constructed at Scottsbluff, Nebraska, by Terry Carpenter, Inc., will operate under license from Gasoline Products Company, Inc. The license for the cracking plant has been signed and Gasoline Products Company and The M. W. Kellogg Company are supplying the process design for the plant.

The cracking plant will have an initial capacity of 600 bbl. per day of crude oil. Lance Creek crude will be processed. The plant is being built by The L. S. Gregory Company, Tulsa, Oklahoma.

A line of low-pour gas oils is to be made in addition to gasoline and a marketable grade of coke. Construction is expected to be completed in August.

●

Shell Oil Company plans the removal of its Hammond, Indiana, refinery to Wood River, Illinois, it is announced. The plant site at Hammond and some of the equipment will be utilized as a terminal for distribution of gasoline.

●

Johnson Oil Supply Company will construct a refinery at Gary, Indiana. It will be a skimming plant and will have a capacity of 1000 to 1500 bbl. per day.

●

Warren Petroleum Corporation has completed its gasoline plant in the Fairbanks field, Harris County, Texas. The plant is approximately ten miles northwest of Houston and initially is manufacturing 12,800 gal. of 26-lb. Reid vapor-pressure gasoline per day. The volume of gas used totals about 20,000,000 cu. ft. per day.

Additional wells are to be connected to the plant until the total is 200 wells, at which time the output of the plant will be 25,000 gal. per day.

F. E. Thompson, who has been in charge of the Warren Petroleum Corporation's butane operations in the East Texas field, is superintendent of the new unit.

●

Model Oil and Refining Company will soon complete its 2500-bbl. refinery at Kilgore, Texas, it has been announced.

The contract for construction of the 3000-bbl. refinery of the Consumers Coöperative Association at Phillipsburg, Kansas, has been let to the Mid-Continent Engineering Company, Inc., Guardian Life Building, Dallas, Texas. The plant's equipment will include a Dubbs cracking unit. Crude oil supply will be from the Burnett, Westhuestin, Fike, and Laton pools in Rooks County, and will be transported to the refinery by a 4½-in., 80-mile pipe line. Mid-Continent Engineering will also lay the line. The project is expected to be completed by October 1.

Howard O. Cowden is president of the Consumers Cooperative Association, which has its headquarters at Kansas City, Kansas. Emil Geppelt, Jr., is president of the Mid-Continent Engineering Company, Inc.

●

Tide Water-Seaboard have announced plans to double the originally intended capacity of the recycling plant under construction in the Long Lake field, Texas. When completed the plant will have a capacity of 50,000,000 cu. ft. of gas per day.

●

Republic Oil Refining Company has taken an extension of its cracking license with Gasoline Products Company, Inc., to cover enlargements in its cracking operations at Texas City, Texas, it is announced. Changes recently completed under the supervision of Republic personnel have increased the cracking capacity of the plant about 40 percent without any major equipment additions.

●

R. S. Bryant, independent operator of Dallas and Corpus Christi, Texas, has announced plans for the construction of a recycling and natural gasoline plant in the East Alice field, Jim Wells County, Texas. The plant will have a capacity of 50,000,000 cu. ft. of gas per day, produced from the 4700-ft. and 5100-ft. zones.

Crude Runs to Stills, Gasoline, Gas and Fuel Oil Stocks
Week Ended May 27, 1939

A.P.I. Figures

(Figures in thousands of barrels of 42 gal. each)

DISTRICT	Percent Potential Capacity Reporting	Daily Average Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks	Total Gas and Fuel Oil Stocks
East Coast	100.0	527	85.7	21,642	12,060
Appalachian	85.9	109	85.2	3,581	73
Ind., Ill., Ky.	89.5	464	90.3	13,900	5,383
Okla., Kans., Mo.	81.6	286	83.6	7,586	4,008
Inland Texas	50.3	125	78.6	1,648	1,933
Texas Gulf	89.5	834	93.2	10,423	9,317
La. Gulf	97.3	131	90.3	2,664	2,579
No. La. & Ark.	55.0	42	74.5	515	813
Rocky Mt.	54.2	57	89.1	1,717	682
California	90.0	500	67.1	15,436	96,013
Reported	85.8	3,075	84.0	79,112	133,518
Estimated Unreported		330		5,040	2,860
*EST'D TOTAL U. S. MAY 27, '39		3,405		84,152	136,378
*EST'D TOTAL U. S. MAY 20, '39		3,460		84,544	135,794
U.S. B. of M. *MAY 27, '38		3,201		88,394	132,751

*Estimated Bureau of Mines' basis.

Activities in the Oil Fields

Continental Oil Company's No. 1-A-28 J. T. Lynn, a wildcat between the Cooper and Lynn areas in Lea County, has intensified interest in southeast New Mexico. Drilled to a total depth of 3668 ft., the well flowed 450 bbl. of oil an hour in a one-hour test, the flow being between casing and drill pipe. After 2-in. tubing was set at a depth of 3659 ft., the well flowed 71 bbl. an hour through ¾-in. choke on a three-hour test. It is believed this discovery eventually may prove to be a link between the Lynn and Cooper areas, although at present it is looked upon as opening a new pool.

●

Norton County, Kansas, has its first oil production as a result of Power and Olson's No. 1 Van Patten having been brought-in as a 200-bbl. per day producer. The gravity of the oil is 20. The well was drilled to a total depth of 3664 ft., into the Arbuckle lime, which, however, was found dry. The well was then gun-perforated in the Kansas City lime at a depth of 3474-95 ft. and acidized. The well is 22 miles northwest of the nearest production.

●

Anzac Oil Corporation's No. 4-C Morris, 18 miles north of Coleman, Texas, has proved to be the largest producing well in Coleman County and also a pool opener. The well has established a potential rating of 2250 bbl. per day based on a gauged flow of 228.5 bbl. in two hours and 25 minutes, flowing through 2-in. tubing. Production is from the Strawn sand at a depth of 2174-90 ft. The crude has tested 44 gravity.

●

Continental Oil Company's No. 1 C. E. Shultz, Wabash County, Illinois, flowed 45 bbl. of crude in five minutes in a test made at a total depth of 2492 ft. in the Cypress sand, indicating the discovery of a new producing horizon in the Cowling area. Previous production in the Cowling pool has been from the Biehl sand at a depth of 1710 ft.

The No. 1 Shultz well is two and one-half miles northeast and across the Wabash River from the Cooper pool, Gibson County, Indiana, where production has been found in the Cypress sand at a depth of 2500 ft. and in the McClosky lime at a depth of 2875 ft.

●

A new Prue sand pool appears to have been discovered in Osage County, Oklahoma. Charles Petroleum Company and P. A. Holbert No. 1 Pierce, SW NW 10-28-11, flowed 200 bbl. of oil on a four-hour test from a total depth of 991 ft., drilled 48 ft. into the producing formation.

●

Texas Conservative Oil Company No. 1 Minnie Bock is Nueces County's newest discovery. This test was drilled to a total depth of 4050 ft. and the casing gun-perforated at a depth of 3806-16 ft., which is the Miocene zone. The well flowed an estimated 135 bbl. of oil per day through a 5/32-in. choke. The wildcat discovery is two miles north of the Clara Driscoll field and opens the 17th oil field for Nueces County.

●

Engineers of the Gled Oil Company and Russell S. Tarr, whose No. 1 Watkins has opened a new Viola lime pool in Kiowa County, Oklahoma, estimate the well as good for 90 to 100 bbl. of oil an hour on open flow. It was drilled to a total depth of 1055 ft., killed, and reopened after tubing had been run to bottom. Being tested after reopening it indicated the above production.

●

W. C. McBride, Inc., No. 6 Lee in the Salem field, Marion County, attains the honor of being the largest producing well in the new Illinois fields. Production is from the McClosky lime and after being acidized the test was rated as a 6000-bbl. per day well.

●

The Rio Bravo field, California, has been given a one-fourth mile extension to the northwest by the Superior Oil Company's No. 1 Moodie. Production is from a depth of 11,529-50 ft.

AVERAGE CRUDE PRICES

California		Louisiana	
Kettleman Hills	$1.19-1.43	Rodessa	$1.05
Playa Del Rey	.80-1.16	Gulf Coast	.74-1.20
Coalinga	.70- .90	North Louisiana	.73-1.05
Signal Hill	.80-1.21		
Montana	.90-1.10	Illinois	1.05-1.15
Wyoming	.35-1.30	Kentucky	1.10-1.20
Colorado	.90- .98	Indiana	1.05
New Mexico	.77-1.00	Ohio	
Texas		Lima	.90
North Central	.71-1.03		
Panhandle	.67- .96	Michigan	.70- .97
West Texas	.53- .95		
Gulf Coast	.79-1.28	Pennsylvania	
Darst Creek	.96	Bradford	2.00
East Texas	1.10	Southwest	1.65
Talco	.55	Eureka	1.59
Kansas	.60-1.10	Buckeye	1.55
Oklahoma	.60-1.10	Corning	1.02
Arkansas	.73	Canada	2.10-2.17

DAILY AVERAGE CRUDE OIL PRODUCTION

Data Supplied by A.P.I.

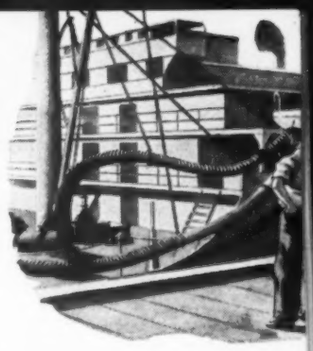
(Figures in Barrels)

	[1]B. of M. Calculated Requirements (May)	Week Ended May 27, 1939	Week Ended April 22, 1939	Week Ended May 28, 1938
Oklahoma	455,800	449,750	451,600	439,650
Kansas	152,600	161,750	171,000	143,550
Panhandle Texas		70,000	74,100	65,050
North Texas		86,500	84,450	74,200
West Central Texas		31,700	31,300	27,500
West Texas		234,150	229,650	177,750
East Central Texas		97,550	104,750	92,550
East Texas		446,250	446,650	362,550
Southwest Texas		259,200	256,650	203,900
Coastal Texas		236,650	226,600	184,300
TOTAL TEXAS	1,406,100	1,462,000	1,454,150	1,187,800
North Louisiana		72,850	75,300	78,450
Coastal Louisiana		195,100	193,500	177,650
TOTAL LA.	261,600	267,950	268,800	256,100
Arkansas	52,900	55,100	52,650	41,500
Illinois	159,700	222,300	174,500	139,600
Eastern (not incl. Illinois)	102,900	99,250	98,750	
Michigan	50,000	63,850	61,100	53,250
Wyoming	64,200	60,700	57,540	51,850
Montana	16,100	14,650	14,350	13,300
Colorado	5,200	3,950	3,550	3,950
New Mexico	115,500	110,500	108,100	90,400
TOTAL EAST OF CALIF.	2,842,600	2,971,750	2,916,000	2,420,950
California	582,600	613,500	610,700	677,700
TOTAL U. S.	3,425,200	3,585,250	3,526,700	3,098,650

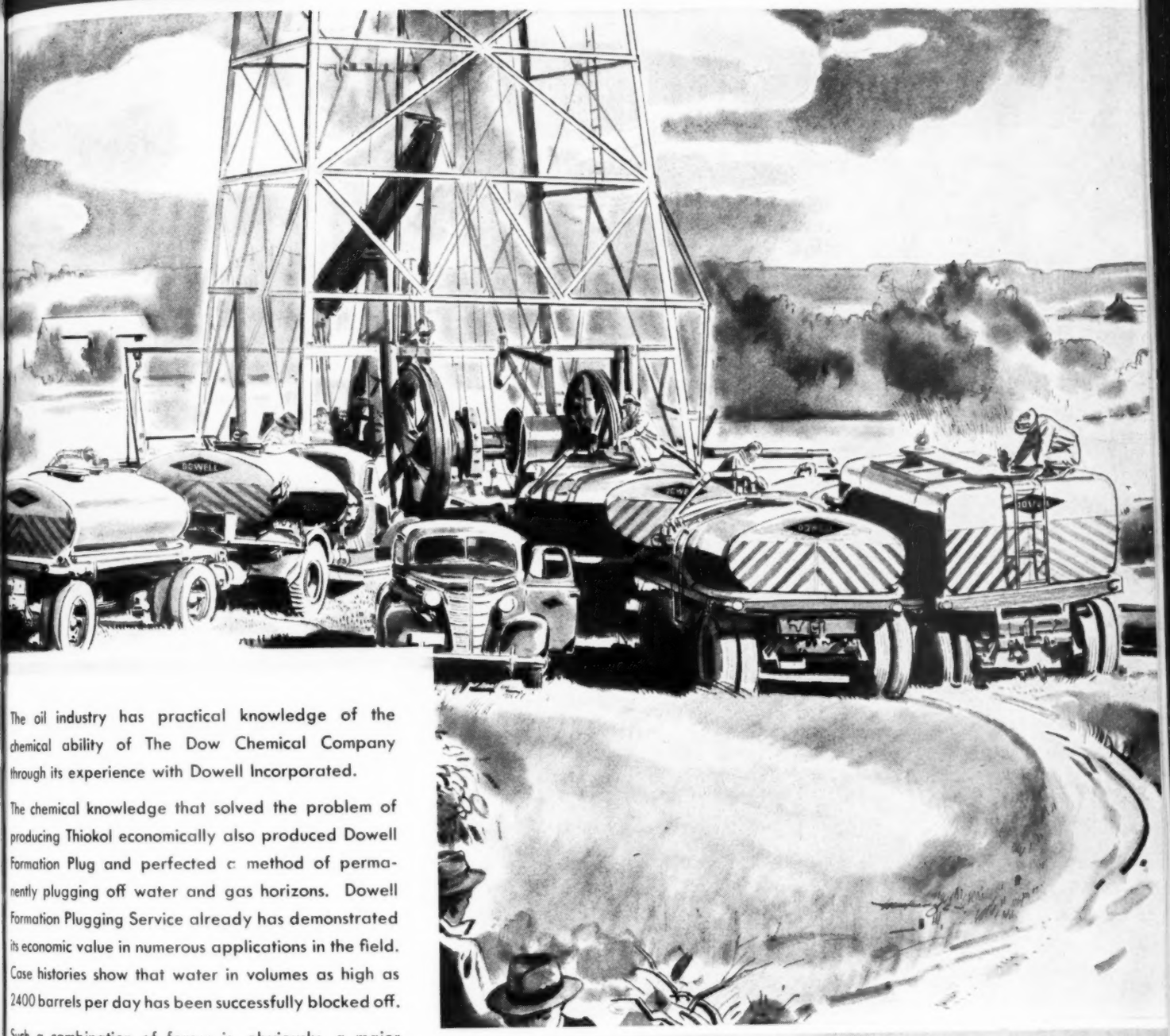
[1]These are Bureau of Mines' calculations of the requirements of domestic crude oil based upon certain premises outlined in its detailed forecast for the month of May. As requirements may be supplied either from stocks, or from new production, contemplated withdrawals from crude oil inventories must be deducted from the Bureau's estimated requirements to determine the amount of new crude to be produced.

A NEW DEVELOPMENT for The Dow Chemical Company is the manufacture of "Thiokol," a synthetic rubber. This man-made rubber resists the action of oil, water, sunlight and air—the enemies of natural rubber.

Hose made of, or lined with, Thiokol is today widely used in the handling of petroleum products.



TRADE DOW MARK



The oil industry has practical knowledge of the chemical ability of The Dow Chemical Company through its experience with Dowell Incorporated.

The chemical knowledge that solved the problem of producing Thiokol economically also produced Dowell Formation Plug and perfected a method of permanently plugging off water and gas horizons. Dowell Formation Plugging Service already has demonstrated its economic value in numerous applications in the field. Case histories show that water in volumes as high as 2400 barrels per day has been successfully blocked off.

Such a combination of forces is, obviously, a major influence in the oil-producing industry. Already untold millions of dollars in additional recovery are credited to Dowell methods and materials. And what has been, and is being done, by Dowell is only an indication of what Dowell will do in the future.

DOWELL INCORPORATED

General Office: KENNEDY BUILDING, TULSA, OKLAHOMA

Subsidiary of THE DOW CHEMICAL COMPANY

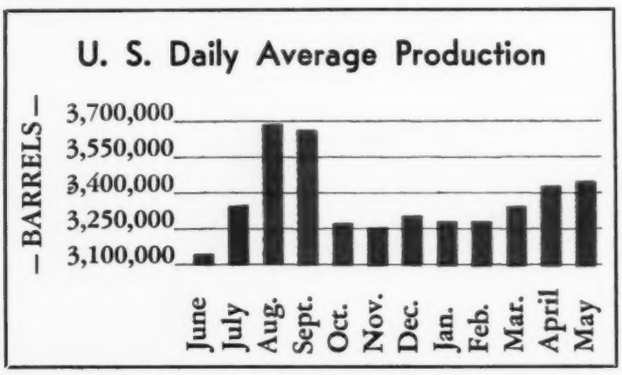
Look to

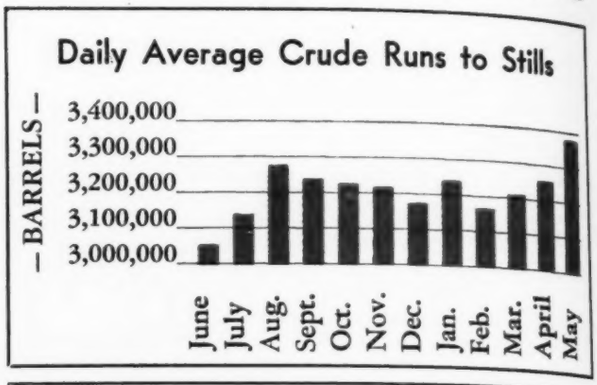
Oil men who attend the Golden Gate International Exposition are cordially invited to visit the Dowell exhibit in The Dow Chemical Company Booth.

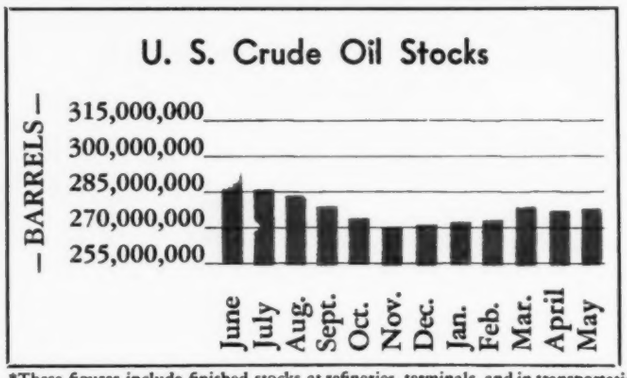
DOWELL

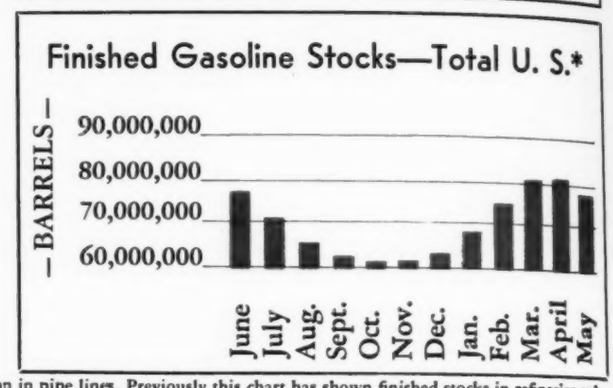
OIL AND GAS WELL CHEMICAL SERVICE

Petroleum Statistics and Field Activities









*These figures include finished stocks at refineries, terminals, and in transportation in pipe lines. Previously this chart has shown finished stocks in refineries only. Above statistics by the American Petroleum Institute.

Summarized Operations in Active Fields for May, 1939

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
East Texas	31	31	11	25	3500-3700	2	40	Rotary
Duval County	41	28	3	12	1554-2900	2	22	Rotary
Ector County	40	37	7	51	3675-4377	2 and 3	32-36	Rot.-Cab.
Panhandle	37	36	24	68	1700-3900	2	40	Rotary
Refugio County	15	14	3	8	4900-5900	2	38	Rotary
Nueces County	19	16	2	5	3922-5878	2 or 3	21-54	Rotary
Winkler County	12	12	3	12	2850-3450	2 and 3	30-38	Rot.-Cab.
K. M. A. Field	27	26	30	48	3730-3935	2	42-43	Rot.-Cab.
OKLAHOMA								
Oklahoma City	3	2	1	2	6450-6682	3	38	Rotary
Fitts Pool	16	14	2	10	1800-4488	2 or 3	38	Rotary
KANSAS								
Russell County	22	20	4	22	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	22	19	5	21	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	11	5	3	17	3290-3518	2	39-42	Rot.-Cab.
ILLINOIS								
Central Illinois	320	247	310	109	1425-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	45	42	6	70	3150-4030	3	30-34	Rot.-Cab.
CALIFORNIA								
Kettleman Hills	3	3	2	12	8300-8730	3 or 4	40	Rotary
Wilmington	16	16	4	20	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for May, 1939

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1938 (In Barrels)
	May	April	May	April	May	April	May	April	May	April	
Arkansas	12	12	11	10	24	15	22	14	26	22	18,211,617
California	96	93	81	77	102	98	89	77	179	180	249,918,001
Colorado	2	3	1	1	....	....	2	2	24	25	1,371,687
Illinois	322	210	249	167	....	....	310	†303	109	97	23,306,000
Indiana	19	11	8	6	....	....	12	1	58	45	965,900
Kansas	113	90	90	65	186	98	42	30	189	141	58,795,545
Kentucky	53	51	27	21	....	....	9	7	96	103	5,828,650
Louisiana	94	73	55	53	149	59	58	49	190	146	94,941,537
Michigan	140	101	82	58	158	92	29	34	141	156	19,140,966
Mississippi	1	0	0	0	....	....	2	4	4	3	Gas Prod.
Montana	11	13	11	10	....	....	5	5	48	52	4,858,458
New Mexico	57	42	47	34	....	....	18	20	129	120	39,902,263
New York	35*	38*	32*	37*	....	....	10	4	32	6	5,040,600
Ohio	82	49	57	36	....	....	41	35	136	130	3,292 100
Oklahoma	233*	158*	174*	110*	229	162	40	34	301	256	171,312,098
Pennsylvania	109*	112*	103*	107*	....	....	....	....	....	....	17,431,500
Texas	837	722	591	521	935	805	267	245	962	884	473,304,662
West Virginia	38	32	33	27	....	....	20	18	75	73	3,700,375
Wyoming	12	4	8	3	....	....	6	7	69	65	19,005,638
Total	2266	1814	1660	1343	1783	1329	982	889	2768	2504	1,206,827,597

*Includes water-intake and pressure wells.
†Includes 234 rigs standing and 69 rigging up.

IT is the mark made by the Rockwell Hardness Testing Machine, and you will find it on every single Flupaco Valve Seat that leaves our factory. For in manufacturing Flupaco Pump Valves we do not merely check a few seats picked at random out of each batch. We carefully test every single valve seat—and each is held to within ONE point of required hardness.

This unusually rigid test is your assurance of absolute uniformity in every Flupaco Valve Seat and Ball that you buy . . . your assurance that each will give maximum performance under the most severe operating conditions. No matter what type of pump you are using you can get the added efficiency and longer life of Flupaco Seats and Valves. They are made in both the ring and flat types—in stainless or alloy steels—for all makes of pumps. Order a supply today and watch your pumping efficiencies go up . . . your maintenance costs drop!

FLUID PACKED PUMP CO. BOX 64, LOS NIETOS, CALIFORNIA, U.S.A.

Mid-Continent and Texas Distribution

MID-CONTINENT: FLUID PACKED PUMP CO., 2 S.E. 29th Street, Oklahoma City, Oklahoma

GULF COAST HEADQUARTERS: 3205 Harrisburg Blvd., Houston, Texas

Major Pipe Line Activities

NEGOTIATIONS now underway may result in the Bolivian Government constructing two pipe lines, one 350 miles and one 35 miles in length. A concession granted recently by the Paraguayan Government has given Bolivia an unqualified monopoly to refine crude oil and supply all Paraguay's requirements for a period of 30 years. As a result of this agreement Bolivia is offering to supply petroleum to Germany in a barter deal, accepting German manufactured goods, especially machinery, in exchange. The deal would involve the sum of $15,000,000, the amount Bolivia estimates is necessary to lay the two pipe lines and erect a refinery in Paraguay. The crude supply would be principally from the expropriated oil wells of the Standard Oil Company in Bolivia, although the agreement to supply Paraguay with petroleum products for a period of 30 years did not specify that the crude must necessarily come from Bolivian fields.

The deal between Bolivia and Paraguay was made possible by a treaty between Argentina and Bolivia whereby Argentina permits transit of Bolivian petroleum through Argentine territory so long as the Bolivian oil fields are not returned the Standard Oil Company.

The plan is to lay a 350-mile pipe line across the Chaco territory and construct a refinery in Paraguay. From the refinery such Bolivian products as are not required by Paraguay could be shipped down the Paraguay and Parana rivers to Buenos Aires for shipment to Europe. Paraguay, incidentally, has agreed to charge no export tax nor make other levies on petroleum products shipped from the Bolivian-operated factory.

The 35-mile line would be laid from Bolivian oil fields to the railhead of the Argentine State Railways at Tobatirenda, just south of Yacuiba on the Bolivian frontier. From there it would be moved by rail to the Argentine town of Formosa, situated on the Paraguay River, then shipped to Asuncion by boat. This route would be used for the movement of crude oil from Bolivia pending completion of the longer line.

The Paraguayan petroleum monopoly was granted to the Bolivian Petroleum Board, which is an autonomous organization of the La Paz government known as the Y. P. F. B. (Yacimientos Petroliferous Fiscales Bolivianos). Paraguay has granted the Y. P. F. B. two free zones of 5000 acres each on the western bank of the Paraguay River. The one opposite the Paraguayan military base at Concepcion would be the terminus of the Chaco pipe line, the other, at Villa Hayes, the site for the refinery. A strip of land 325 ft. wide across the Chaco has been granted for the pipe line right-of-way.

The agreement provides that the refinery shall be completed in 18 months and the Chaco pipe line in five years. At the end of 30 years the Paraguayan Government is to assume control of the refinery at cost minus depreciation, but the pipe line will remain the property of the Y. P. F. B.

●

Mid-Continent Engineering Company, Inc., Dallas, Texas, has been awarded a contract by the Consumers Coöperative Association, Kansas City, Kansas, to lay a 4½-in., 80-mile pipe line from the Burnett, Westhuestin, Fike, and Laton pools, Rooks County, Kansas, to Phillipsburg. The line will be used to transport crude oil from these fields to a refinery to be constructed by the Consumers Coöperative. The project is expected to be completed by October 1.

●

The Memphis Natural Gas Company has begun the installation of cathodic protection on 28 miles of its 210-mile, 18-in. transmission line that runs through four states between Monroe, Louisiana, and Memphis, Tennessee. Upon completion of this program, which embraces a section north of Greenville, Mississippi, there will be 117 miles of the total 210 miles protected cathodically.

All cathodic protection on the Memphis Natural Gas System has been designed and installed under the supervision of Robert J. Kuhn, consulting engineer of New Orleans, Louisiana.

●

The Northern Pipe Line Company, subsidiary of the Arenac Oil and Gas Company, has awarded a contract to the H. L. Gentry Engineering Company, Jackson, Michigan, for construction of a 47-mile, 6-in. electrically-welded gas line from the Arenac County gas field to Midland, Michigan. At that point it will tie-in with the Consumers Power Company's Mt. Pleasant to Saginaw 8-in. line. From the terminal at Midland, gas can be diverted either to Saginaw or Bay City.

The Arenac field, although discovered in 1936, at present has no commercial outlet. Production is from the 1300-ft. Berea sand zone and the estimated open-flow capacity of the field is 40,000,000 cu. ft. per day.

Construction work began on the line the early part of this month.

●

The Michigan Gas Transportation Company, affiliate of the Panhandle Eastern Pipe Line Company, has won a two-year fight for a permit to lay a 21-mile line from Trenton to Ann Arbor, Michigan, a lateral to its trunk system from Texas and Kansas gas fields to Detroit. A permit to lay the line originally was applied for in 1937 but was opposed by the Independent Gas Producers Association of Michigan on the grounds that approval of the line would be to give Texas- and Kansas-produced gas a preference over that produced in Michigan. The original application was denied in 1938 by the Public Utilities Commission. That body, however, was replaced recently in a legislative act. The Public Service Commission, which took its place, has granted the permit.

●

The Michigan-Toledo Pipe Line Company is installing a new pumping station at Dundee, Michigan, on the company's 8-in. line from Mt. Pleasant, Michigan, to Toledo, Ohio. Pumping equipment will consist of two 375-hp. Diesel engines driving through speed increasers two centrifugal pumps designed to operate at a pressure of 825 lb.

The company's Chelsea station is being enlarged by the addition of a 375-hp. Diesel engine driving through a speed increaser a centrifugal pump.

The completion of this program will provide a capacity of 24,000 bbl. per day from Mt. Pleasant and 36,000 bbl. per day from Chelsea, according to D. W. Hewitt, superintendent.

●

It is announced that Mexico plans to lay a pipe line to Salina Cruz on the west coast in order to make crude oil available to foreign ocean-going tankers. The line will be an extension of the present pipe line from Tampico to Puerto Mexico on the east coast. From the latter point, the new line will be constructed westward to Salina Cruz on the Bay of Tehauntepec. The Bay is being dredged to accommodate deep-draught vessels. The project is believed to be Mexico's answer to the boycott of its oil by United States and British interests. Japan, principal purchaser of crude oil on the Pacific Coast, may divert most of its purchases from California ports to take advantage of lower-priced Mexican production.

P 551.21

THE Petroleum Engineer

JUNE, 1939

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

The First Horizontal Oil Well*

Details of the method of horizontal drilling—this method of drilling, permitting commercial production from sands of very low saturation, may suggest a new method of recovery in shallow or depleted fields.

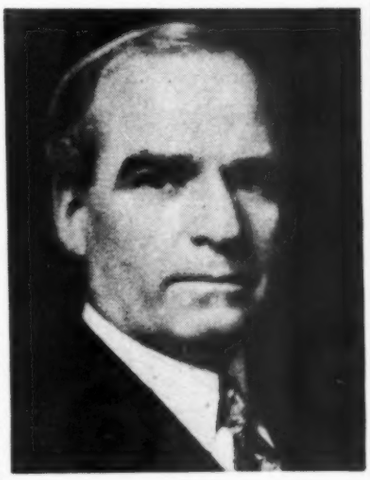
By LEO RANNEY
Petroleum Engineer

IT is flattering to a fellow engineer that so many of you would leave your own State and come so great a distance to see the experimental application of an idea. It may be possible that you have seen today the humble beginning of what may be developed into a chapter of oil history.

You are looking for new things. The engineer who became a hermit 30 years ago is as dead as old King Tut, and may as well remain in seclusion. The world has little use for him. In the oil industry the man who has learned nothing new in the last ten years may as well retire — if losses have not already retired him. The panorama of oil production changes constantly—the eternal search for new methods of producing oil at a smaller cost per barrel, and of recovering a larger percentage of the oil in the ground. That is true conservation.

The production engineer is forever

*To be read before the Engineers' Society of Western Pennsylvania, at Marietta, Ohio, June 23, 1939, following a visit to the first horizontal oil well. Methods and apparatus described herein are covered by U. S. patent applications.



LEO RANNEY

is president and chief engineer of the Ranney Oil Mining Company, New York City, although he is now residing at McConnelsville, Ohio—Graduated from Iowa State Teachers College in 1905 and from Northwestern University in 1911—Is the inventor of processes for mining oil from depleted fields, for commercial recovery of natural gas (firedamp) from coal seams, for producing ground water, and for the creation of underground gas reservoirs, to mention but a few of his accomplishments.

Preparing to fill 15-ft. fiber cartridges with gelatin

groping for a better way to produce oil. Whenever he stops to think that today he is leaving more than half the oil in the ground—then he seeks almost a revolutionary way. So an entirely new method of attack, simple in plan, easy to install, having worthwhile possibilities, especially if it has been successfully tried, at least merits investigation and trial.

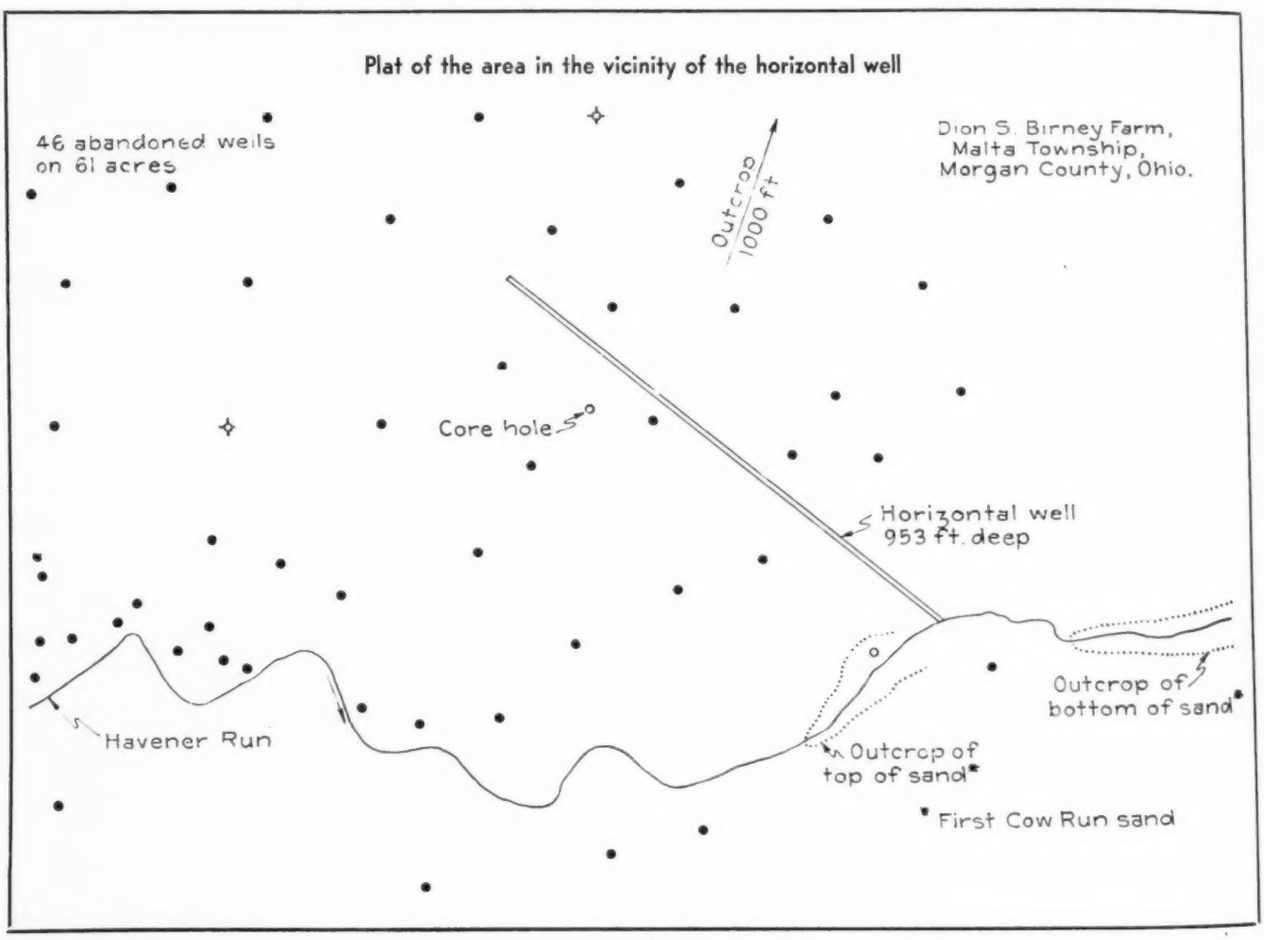
A vertical well may be drilled 2000 ft. deep to penetrate a sand 20 ft. thick; then only 1 percent of the drilling is in a productive horizon and 99 percent is in formations that can produce nothing but salt water — and grief. These figures are substantially correct—except when half your wells are dry holes, and then only one-half of one percent of your work has a Chinaman's chance of reward. These figures indicate something is wrong somewhere.

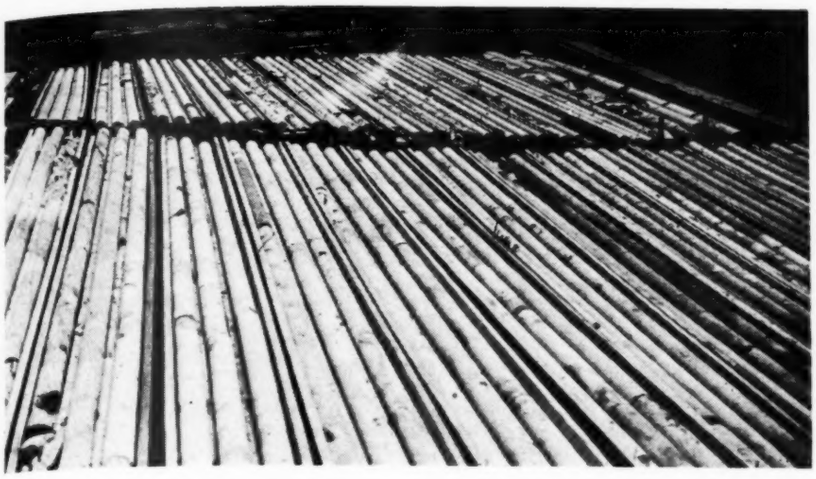
If one well is drilled on a 5-acre spacing in this 20-ft. sand, then you expose only 4 linear ft. of oil sand per acre of surface area. Still more astounding—the oil from 4,356,000 cu. ft. of sand must drain into a 6-in. hole 20 ft. long. This can hardly be called effective exploitation, viewed in this manner.

Let us assume you do "get a break" and find oil in your well. Even then, in a short time your production is down to a bbl. per day, then to a half-bbl., then to a quarter, until finally you find yourself pumping a well an entire week to get one bbl. of oil. Old Lady Trouble is your constant companion—powers, shackle rods, sucker rods, pumps, cups, tubing, casing, cleaning-out jobs. Maybe the time has really come to try an entirely different line of attack.

Today you have seen the first horizontal oil well ever drilled. It is the initial effort in a development that I believe will become important. This well was drilled in the outcrop of the First Cow Run Sand in Havener Run to save the cost of sinking a shaft. It is known that oil has been seeping

Plat of the area in the vicinity of the horizontal well


46 abandoned wells on 61 acres
Dion S. Birney Farm, Malta Township, Morgan County, Ohio.
Outcrop 1000 ft.
Core hole
Horizontal well 953 ft. deep
Outcrop of bottom of sand*
Havener Run
Outcrop of top of sand*
* First Cow Run sand



Nearly 1000 ft. of core taken from a well having a sand about 20 ft. thick

from the exposed sand face—probably for centuries. It was not known, however, until after the first branch of the well had been drilled, and a vertical core, taken 700 ft. from the face, had been analyzed by Dr. Fettke, that the average saturation of the pay was only 15.9 percent. Whoever heard of a successful vertical well in a sand having that saturation, unless some sort of repressuring was employed?—but a horizontal well in such a sand is something entirely different.

As engineers, you are interested in some of the details of drilling. The well is 2⅝ in. in diameter, except where shot. It was planned as a 3-in. hole. During drilling in this soft sand, gravity carried the bit downward very rapidly. Fourteen times it was necessary to turn the hole upward. Usually the upward lift was one-half in. in ten ft.

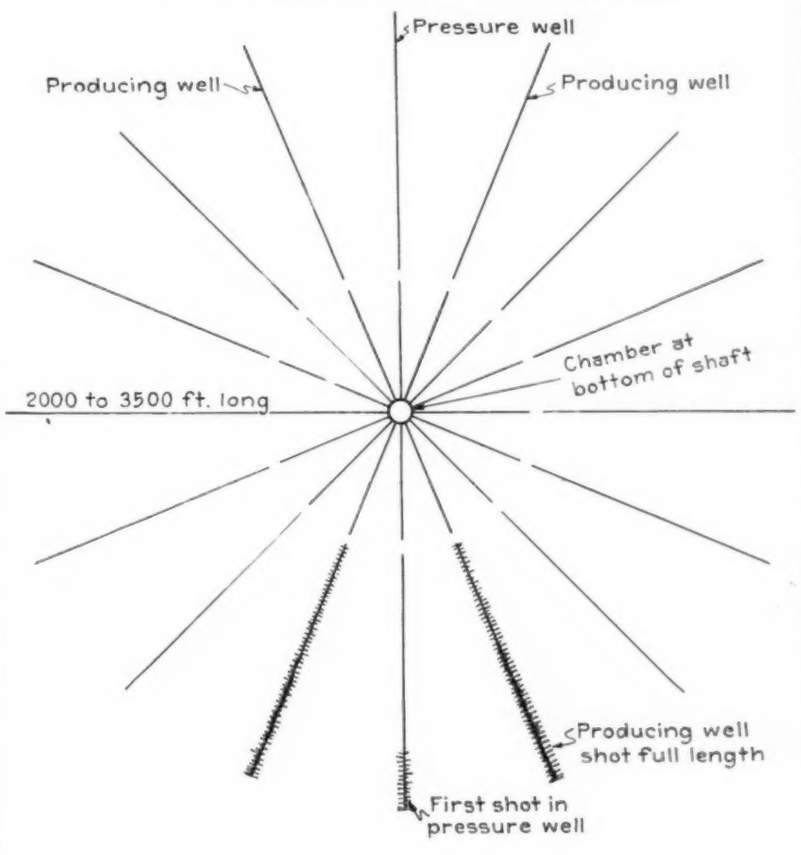
By the method of elevational control that is now employed the elevation of the hole could have been kept within one inch of the level of the mouth or on any desired inclination at all times; however, in feeling for the producing formation, at one point the hole was 4 in. above the mouth, and at another 17 in. below the mouth of the well. Later, to test the limit of ability to turn the hole upward or downward within a short distance, it was inclined upward at a rate of three in. in ten ft. Then to permit passage of the core barrel an elliptical hole was drilled at that point.

The point of lowest elevation in the 902-ft. hole is 630 ft. from the surface. Since the best pay is in the lower part of the sand, the well was branched off, turned down at that point (630 ft.), and passed through a non-productive substratum one ft. thick, and into the lower pay. The hole was leveled-off and directed along this lower pay to a depth of 953 ft. from the surface. It would have been an easy matter to drill a sinuous hole through the non-pay streak to tap the pay on both sides. It was believed, however, that when the hole was shot (below this tight streak), fissures would be created through it and into the upper sand. Apparently this happened.

As the technique of surveying the hole and controlling the bit was slowly mastered, the rate of drilling gradually increased. At first, including time required for experiments, only 40 ft. per 7-hr. shift was averaged. The rate was then increased to an average of 57 ft. per shift. Just before drilling was completed as much as 106 ft. of hole was drilled in seven hours. Often the drill advanced one ft. per minute. Many times, in coring, the 31-ft. core barrel would be entirely filled with one unbroken core, a record, so far as we know, for cores less than two in. in diameter.

Frequently the drill passed from pay to non-pay sand sometimes within a distance of two inches. Three different times small pools of oil were tapped—once the oil gushed three ft. out of the mouth of the well casing. It is almost incredible that a sand depleted by centuries of seepage, then tapped by vertical wells drilled one to each 1½ acres, and later subjected to vacuum

Illustrating the radial pattern of wells drilled horizontally from a central chamber in a property developed by the Ranney method



and then blown with air, should still contain untapped pockets of oil.

When the time came to shoot the well we were confronted with the fact that only about 100 ft. of the 565-ft. shot would explode if fired at one end of the charge. This is because (1) compressed gelatin will not explode and (2) the wave of compression travels faster than the wave of detonation. This problem was solved for us by a leading explosives manufacturer by running a charge of TNT beside the gelatin for the full length of the shot. The wave of detonation in TNT travels at the rate of 19,000 ft. per sec., which is faster than the rate of travel of the compression wave. Du-Pont 80 percent high-velocity gelatin was used with perfect results.

The earth at the ground surface above the shot raised momentarily 1½ in. by the force of the explosion. It is logical to assume that the upward movement was considerably greater than the downward movement below the hole. Even so, if the upward movement at the earth's surface, 220 ft. above the shot, was 1½ in., the movement in the sand itself must have been even greater. At one instant the width of horizontal cracks above the shot was at least 1½ in. Vertical cracks must therefore have extended across the sand above the hole.

As to the length of lateral or horizontal cracks, the only concrete evidence was that afforded by the behavior of a vertical well 40 ft. to one side of the horizontal well and 700 ft. from the face. Before the shot it required three days for the effect of vacuum in the horizontal well to be felt in the vertical well. After the shot, the effect of vacuum reached the vertical well in ten minutes and was never more than three inches less than the vacuum applied at the mouth of the horizontal well. This appears to be tangible evidence that at least one wide lateral crack extends a minimum of 40 ft. outward from the horizontal well, and probably much farther, as a result of the shot.

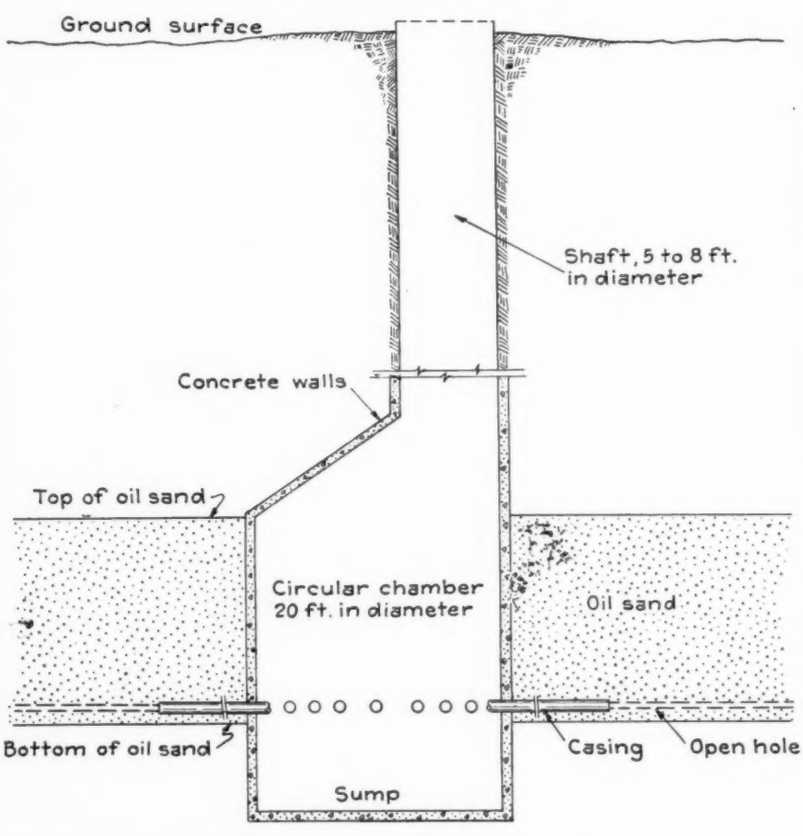
In addition to the new exposure of sand in the fractures caused by the shot, in one-tenth sec. the hole itself was enlarged more than eight times. In other words, the shot in the 565 ft. of hole increased the exposed sand area from 390 sq. ft. to more than 3100 sq. ft. In digging an oil mine in Texas some years ago curiosity impelled me to drive a tunnel to an old nearby vertical well that had been shot. It was found that the diameter of the well had been increased by the shot only from 6 in. to 8 in.; the reason being that the shot had to break against the "grain" of the rock.

Apparently, then, one effect of developing an average property by drilling and shooting horizontal wells, as compared with development by vertical wells, is about as follows: If 6-in. vertical wells expose 4 ft. of sand per acre and shooting enlarges the holes to 8 in., then a total sand area of about 8 sq. ft. per acre of surface area will have been exposed. If horizontal wells are drilled and shot, the sand exposure will be from 600 to 800 sq. ft. per acre, when only 100 ft. of hole per acre is drilled. Further experience probably will show that it will be more profitable to drill much more hole than 100 ft. per acre of land. Drainage probably will increase directly with the amount of sand exposure, but to what extent only experience will teach us.

Drilling horizontally in outcrops never can be adopted widely because there are not many seeping outcrops, and saturation there is bound to be less than in the middle of an oil field.

Pumping sand from the well during the cleaning operation

Diagrammatic sketch of shaft and central chamber from which horizontal wells radiate



The real development must come, if it comes, by drilling horizontal wells from shaft-bottoms or from tunnels. Strange to say, a coal miner is afraid to climb a 50-ft. derrick but the oil man will tell you, "I'll climb a derrick 200 ft. high but I never want my head to go below ground until they wrap me in my wooden overcoat." The oil operator is prejudiced against a hole large enough to fall into.

Shafts are sunk every day, however. There is one in South Africa more than 9000 ft. deep—and men go down into them and actually come up alive. A shaft for horizontal drilling purposes need be only six to eight ft. in diameter, preferably circular in cross-section. It may be put down by the Newsom method at a cost of, say $50 per ft. It may be sunk and lined with concrete by standard methods for approximately $100 per ft. The working chamber at the bottom should be about 20 ft. in diameter and must be lined with concrete. There must be a sump at the bottom.

Horizontal wells are drilled into the more productive part of the sand from this chamber. The first 100 ft. of each horizontal well is cased with a pipe four or five in. in diameter, grouted-in and extending into the chamber, and equipped with a gate valve. If gas still exists in the sand, or if much water is present, drilling is done through a stuffing-box. A vertical pipe connected on top of the casing behind the stuffing-box carries any gas to the surface, and a pipe connected to the underside of the casing carries away drill-water and cuttings. No free gas or oil is allowed to enter the working chamber.

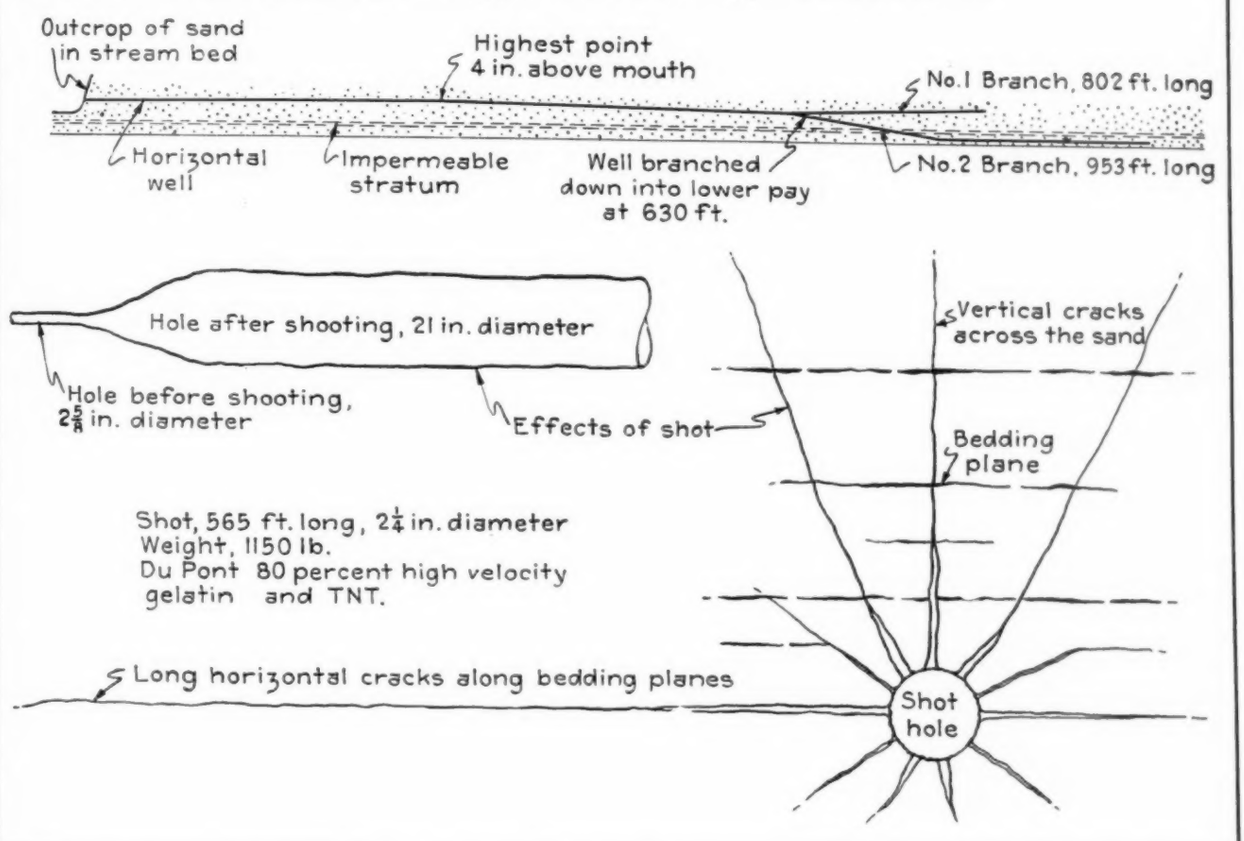
Core barrels 50 ft. long are recommended. A survey of the well is taken with every core, automatically and instantaneously. Every foot of the hole is platted. The surveys indicate when the hole should be turned upward or downward to keep within the substratum that vertical coring has shown to be the proper one to follow. It is as easy to turn a horizontal hole upward at a "depth" of 3000 ft. as it is at 100 ft. The only limits to the length of a well are (1) the distance to the property line and (2) the strength of the drilling machine. Each vertical shaft should permit from 600 to 800 acres of sand to be tapped and drained effectively.

Three men are required to operate a drilling machine. When working from a shaft-bottom, one of these men should be on top. To drill a 3000-ft. well 3 in. in diameter, a 75-hp. enclosed electric motor is preferred. Using the new method of drilling it is expected to drill more than 100 ft. per day. Any well may be branched at any time—upward, downward, or to the right or left.

When, say, 16 horizontal wells are to be drilled from a shaft-bottom, alternate wells (the producing wells) are drilled first. Each producing well, when completed, is shot to within 200 ft. of the shaft, and is immediately put on production. After the first two producers are completed it is estimated that revenue from production will pay for the drilling cost of the other 14 wells so that no more new capital will have to be advanced.

From experience in shooting the First Cow Run Sand horizontally, it seems safe to say that in a similar sand

Top of sketch shows the manner in which two productive zones were tapped in the horizontal well at Havener Run. Bottom of sketch shows the effect of shooting parallel to the bedding planes of the formation


Outcrop of sand in stream bed
Highest point 4 in. above mouth
No.1 Branch, 802 ft. long
Horizontal well
Impermeable stratum
Well branched down into lower pay at 630 ft.
No.2 Branch, 953 ft. long
Hole after shooting, 21 in. diameter
Hole before shooting, 2 5/8 in. diameter
Effects of shot
Vertical cracks across the sand
Bedding plane
Shot, 565 ft. long, 2 1/4 in. diameter
Weight, 1150 lb.
Du Pont 80 percent high velocity gelatin and TNT.
Long horizontal cracks along bedding planes
Shot hole

a well that is shot will have a diameter of approximately two ft. Such a hole 2865 ft. long would expose about 18,000 sq. ft. of sand, and in the eight producers of the above development there would be an exposed drainage surface of 144,000 sq. ft. of sand, all draining into the one shaft. Such an enormous sand exposure in a producing property is difficult to picture. My own belief is that it should produce oil in paying quantities. If the producing formation is 20 ft. thick, then this area of exposure might be mathematically equal to that of more than 3000 vertical wells. The exposure in the horizontal wells, however, would all be in the more lucrative bottom portion of the sand.

In any development in the eastern states some form of secondary recovery will be required to strip the residual oil from the sand. Alternating with the producing wells in the pattern of horizontal drilling is an equal number of pressure wells of the same length. The pressure wells are shot in a different manner from that used in the producing wells. After a pressure well is drilled it is filled with thin grout and a relatively high pressure is applied for a few minutes. The grout is thus forced a few inches into the sand wall of the well. The surplus grout is then washed from the hole and the wall is left impermeable. The next step is to shoot the far end, possibly 200 ft., of the hole.

One of the piles of sand removed from the well after shooting

Gas, oil, and sand spouting intermittently from the well

After shooting, the pressure well is cleaned-out and pressure is applied. The grout-impregnated wall of the well prevents pressure entering the formation except at the distant end where the shot was concentrated. Any pressure medium that may be used in vertical wells may be even more effectively applied in horizontal wells—air, gas, water, water glass, or even live steam. Though steam has not been used effectively in vertical wells, some engineers favor its trial in horizontal holes, taking advantage of the more favorable conditions.

Because of the large exposed area of sand, it is believed that very low pressures may be applied effectively and that pressure and producing holes may be spaced much farther apart than in present practice. If the shots fracture the sand from top to bottom, in both pressure and producing wells, vertical cracks above the pressure wells will transmit pressure to all levels in the sand. Likewise, vertical cracks above producing wells will drain oil from the full thickness of the productive sand.

The maximum cost of developing a tract of 600 to 800 acres, when the sand is, say, 500 ft. deep, is estimated at $400 per acre; but the amount required to sink the shaft and drill and shoot the first two producers probably will not exceed $100 per acre.

As to production costs, inasmuch as the horizontal wells are self-draining and one man can operate all the wells in one shaft, the gross lifting cost will increase but little with increased production. It is not expected that lifting costs will reach $1.00 per bbl. for many years. It is believed that a Pennsylvania grade recovery of even 500 bbl. per acre in two or three years would repay both development and production costs.

Time permits reference to only a few of the highlights of this experiment, and any one of these could be discussed for hours. The ideas presented here have been developed through many years of study and work in the field. Experience may prove many of them to be faulty, and most of them to be only embryonic; however, here is food for much thought and experiment, and the most fascinating field for research and development that it has ever been my pleasure to enter.

After the well had settled to a steady flow

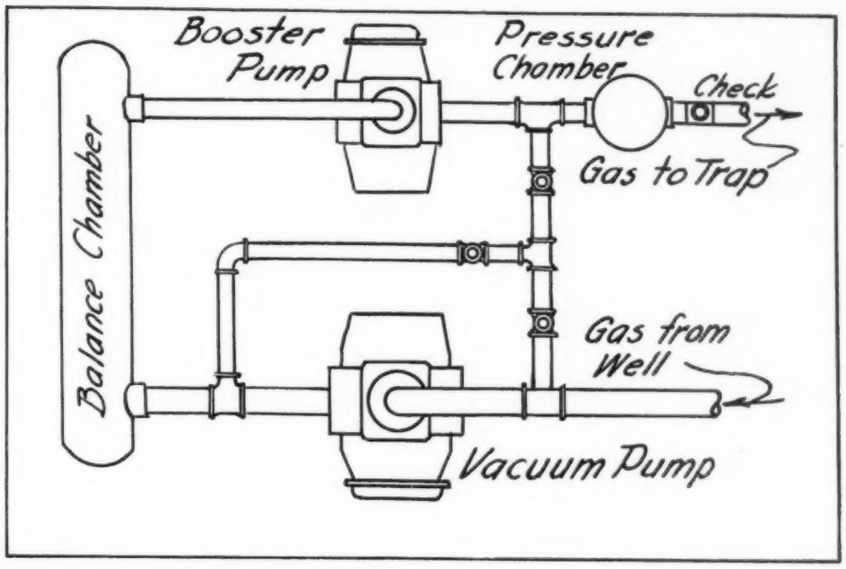


Fig. 1. Hook-up employing rotary-type vacuum and pressure pumps to boost high-vacuum gas into a low-pressure trap

(Arrangement suggested by Sutorbilt Corporation)

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

By
WALLACE A. SAWDON
Pacific Coast and Foreign Editor

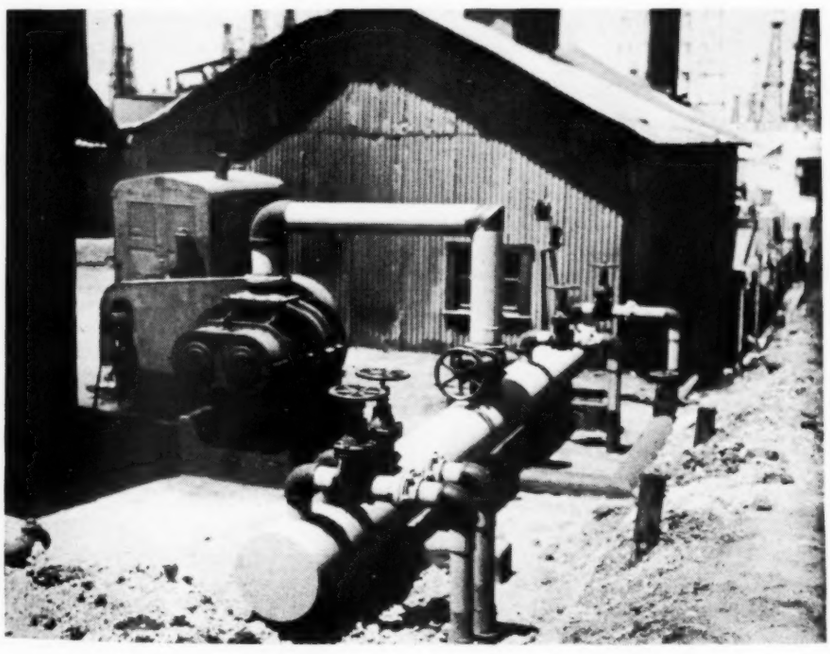
Application of Vacuum to Pumping Wells

Increased recovery of gasoline has been obtained in California fields where practice is employed

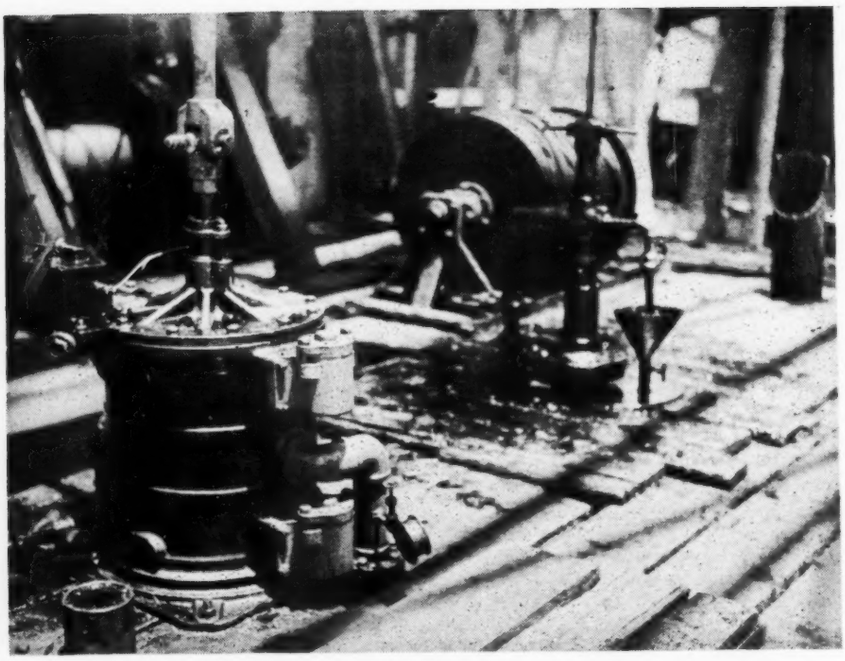
ONE benefit, at least, resulting from the use of high vacuum in pumping wells in several fields of California has been an increase in the gasoline content of the gas produced. Some operators believe vacuum operation also results in increased oil production. Others, whose records show no increase of production, realize the necessity of protecting their production by applying a vacuum as high as that used on adjacent wells. In the closely-drilled town-lot area of Signal Hill, for example, the use of vacuum exceeding 20 in. (Hg) is quite general in the northern and eastern parts of the field. In these areas it is not uncommon to see vacuums to 25 or 26 in. (Hg) maintained in some of the wells.

Gas from virtually all the wells in the Signal Hill field is taken under some amount of vacuum. Most of the gasoline plants maintain from 10 to 14 in. (Hg) at the plant intakes. Two companies maintain approximately 22 in. (Hg) vacuum at the plant intake. One of the latter plants receives gas from at least one well about three miles distant from the plant, maintaining a vacuum of 9 in. (Hg) at the wellhead. The other high-vacuum plant has shorter gathering lines so that a vacuum of not less than 14 in. (Hg) exists at all the wells connected and at the majority of these a vacuum of nearly 20 in. (Hg) is produced. Even with the relatively high vacuum provided by these two plants, auxiliary equipment is sometimes installed for increasing the vacuum to 22-25 in. (Hg) on wells where this amount of vacuum appears desirable.

The spacing of wells so close together that it is sometimes possible to step from one derrick to another has a definite influence on the amount of vacuum carried; and the multiplicity of ownership in these congested areas influences the type of equipment installed for providing the necessary vacuum. When one well is put on high vacuum it is usually necessary to put the ones surrounding it on equal vacuum; then the wells next adjacent to these must be put on high vacuum to protect their production and so on, over a considerable area. The need for this so-called "protection" has been demonstrated by the experience in one well in which no fluid was found in the hole when the vacuum was removed to permit clean-out of the well. This, of course, was an extreme case but it is



This pump is pulling vacuum on three wells, taking the combined gas from the header. The header connection in the background is a by-pass



The vertical-type walking-beam vacuum pump is used on many wells

indicative of the effect of high vacuum under existing conditions in this section of the field.

Some few wells are not noticeably affected by high vacuum. Others cannot be produced under the influence of high vacuum because of fine sand. The latter are usually surrounded by wells produced under high vacuum. In the western and southern parts of the field, high vacuum is not effective as demonstrated by its failure to alter production when applied to some of the wells.

A great many rotary-type gas pumps are being used for pulling high vacuum. These pumps may be direct-connected to engines or driven by V-belt drives. Gas engines properly rated for the duty to be performed are used as prime movers. In the Signal Hill field nearly all vacuum units are belt-driven. Several wells closely situated on a lease may be served by a central unit economically. In many instances, however, an individual unit must be provided for a single well. The choice of equipment for single well vacuum units is usually either the rotary-type pump or the vertical-type vacuum pump powered by means of the walking beam. In other installations the reciprocating-type of gas pump is employed.

Regardless of the type of pump used, the leakage of air into the system must be avoided. Air pulled into the system serves to dilute the dry-gas residue after the gasoline has been extracted. The gasoline content of the gas taken from the casinghead varies widely over the Signal Hill field. From some of the wells in which high vacuum is maintained the gasoline content is sometimes as high as 20 gal. per M cu. ft. (measured at atmospheric pressure). So many plants are processing gas that it is impossible to determine accurately the average gasoline content for the area being produced under high vacuum but it will probably exceed ten gal. per M cu. ft. from wells produced under 22 to 26 in. (Hg) vacuum measured at the wellhead.

It is important in calculating the capacity of vacuum pumps to consider the volume increase that accompanies an increase in vacuum. One cu. ft. of free gas expands to only 1.5 cu. ft. at a vacuum of 10 in. (Hg) but the same volume of free gas will occupy 7.5 cu. ft. at a vacuum of 26 in. (Hg).

The increase in volume of one cu. ft. of free gas, measured at atmospheric pressure=30 in. (Hg), as the amount of vacuum increases is shown in the following table:

Vacuum, in. (Hg)	2	4	6	8	10	12	14	16	18	20	22	24	26
Cu. Ft.	1.07	1.15	1.25	1.36	1.50	1.67	1.88	2.14	2.50	3.00	3.75	5.00	7.50

NOTE: Above values are calculated by the formula:

$$\text{Vol. of gas under vacuum} = \frac{30}{30 - v} \times \text{vol. of free gas}$$

where v = vacuum, in. Hg.

The gas from most of the wells goes directly from the vacuum pump into the vacuum line connecting the well and the gasoline plant. Some of the wells are hooked-up to discharge the gas from the pump into a separator in order to eliminate the reduction in gravity of the oil that results from subjecting the oil to high vacuum. It is claimed by some operators that the gravity of oil produced through a separator is higher than that obtained by production at low vacuum but without employing a separator.

The gasoline obtained from high-vacuum wells is probably more stable than gasoline that is produced under pressure. The lighter fractions that comprise natural gasoline ordinarily are combined with heavier fractions "distilled" from the oil by the high vacuum. Tests of gasoline content in the Signal Hill field as a basis for royalty-payments on gas production are made by the activated-charcoal absorption method and it is found that tests usually check actual plant yields very closely.

Performance of vacuum pumps, as in pressure pumps, is dependent to a great extent upon the differential pressure (or vacuum) across the pump. In many instances a vacuum pump may be pulling a vacuum of from 22 to 26 in. (Hg) on the well or intake side and be required to discharge into a line on which there is a vacuum of from 10 to 14 in. (Hg). These conditions are equivalent to operation under a compression ratio of from 2.5 to 6.5. In hook-ups where the gas is put through a separator after being taken from the well under vacuum, the pressure on the discharge line from the separator is at least a few ounces per sq. in. above atmosphere and the capacity of a vacuum pump may be exceeded. Fig. 1 shows a suggested hook-up employing a booster pump to provide a second stage of compression when it is desired to introduce high-vacuum gas into a low-pressure trap.

So far as is known, no attempt has been made to estimate the effect of high-vacuum operation on ultimate yield or on future production problems in the Signal Hill field. General operating conditions and the necessity of protecting well production against the effect of adjacent vacuum projects has forced the use of high vacuum in the majority of instances.

P 773.
P 515.5

Six angle-type, single-stage, 4-cycle compressor units compress the gas from a pressure of 1200 lb. to 1800-2000 lb.

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

By
FRANK H. LOVE
Managing Editor

South Texas Recycling Plant Has 60,000,000 Cu. Ft. Capacity

Natural gasoline is being extracted by the absorption method at a pressure of 1200 lb. and gas returned to producing zone at 1800 to 2000-lb. pressure—Plant capable of manufacturing motor fuel as well as natural gasoline

ONE of the most recent recycling-gasoline-extraction plants to be placed in operation is that of The Agua Dulce Company, affiliate of The Henderson Company, situated approximately four miles south of Banquette, Nueces County, Texas. Having a maximum capacity of 60,000,000 cu. ft. of gas per day, the plant is taking production from a group of distillate wells at an intake pressure of 1200 lb. and discharging to input wells at a pressure varying from 1800 to 2000 lb.

The plant is unusual in several respects. It is, for example, the first plant to extract natural gasoline by the absorption method at a pressure of 1200 lb. To accomplish this, one of the requirements is an absorption oil having entirely different characteristics from the oil usually employed in an absorption process at normal pressures. Special processing equipment has been designed to prepare this oil and to maintain it at a uniform quality. Patents are now pending on many of the features and for that reason they cannot be discussed in detail. Other points of interest in the process are (1) the manner of regulating gas flow to the compressors and (2) the fact that the plant is capable of manufacturing both natural gasoline and motor fuel.

Present header arrangement is such that the plant can take production from any 12 wells at a time. Three wells are being used for input gas at present, but provision is made so that any well delivering gas to the plant can be converted to an input well without changing the flow lines. The gathering system consists of direct lines from each well to the plant and headers are arranged for distribution of the gas to all absorbers and compressors at uniform pressure, or, if desired, each absorber unit can take delivery from certain wells at varied pressures.

To describe briefly the various cycles, gas is transmitted through a 3-in. line from the field to the plant header, incoming gas being at a temperature of 96° F. The gas is then discharged to the base of the absorbers. From the absorbers the gas is piped to the intake scrubbers prior to entering the compressors. After being compressed, the gas is returned to the input wells through a 4-in. line.

The absorption-oil cycle involves the discharge of lean oil by a high-pressure pump to the top plate of the absorber. Upon leaving the absorber the rich oil passes to a 200-lb. vent tank from which vent-gas is routed to the low-pressure absorber. The rich absorption oil is conducted through a heat exchanger to a preheater, thence to an evaporator. The stripped oil from the base of the evaporator is returned countercurrently through a heat exchanger and is picked-up by a turbine-

driven centrifugal pump that forces the oil through cooling coils to the high-pressure pump. Surplus lean oil is utilized in the low-pressure absorber.

Six angle-type, single-stage, 4-cycle compressor units are employed to increase the pressure from an intake of 1200 lb. to 1800-2000 lb. for reinjection into the producing zone. Each unit has two compressor cylinders of 3⅞-in. bore and 12-in. stroke, and is equipped with exhaust silencers, closed jacket-water system, oilbath intake filters, dual ignition, and electrically-operated safety devices for automatic shut-down.

The six compressor units are arranged in three groups of two each. Each group takes suction directly from one absorber. The rate of gas flow to each absorber is determined by the amount of gas being pumped by the compressors. Thus the flow of gas from the face of the producing sand to the compressors is automatically regulated although there is no mechanical regulation other than that provided by the compressors.

There are three 40-in. O. D. absorbers fabricated with 2-in. steel shells. Each absorber contains double mist-extractors. In addition to these high-pressure vessels there is one 36-in. O. D. low-pressure absorber. The latter is used to process plant gases, the residue from this unit supplying virtually all plant fuel requirements.

Principal equipment in the distillation area consists of 18 heat exchangers and a 60-in. O.D. evaporator. The latter is operated at a temperature of 390° and has internal heating elements and an individual dephlegmator. Provision is made for taking side cuts. Oil cooling and vapor condensing are accomplished by the use of atmospheric-type coolers. Water used in the system is cooled in a 13-bay cooling tower. Make-up water is obtained from a gas-lift well. Before entering the system, the water passes into a scrubber tank. The gas used in flowing the water-well is trapped and used as fuel for engines and boilers.

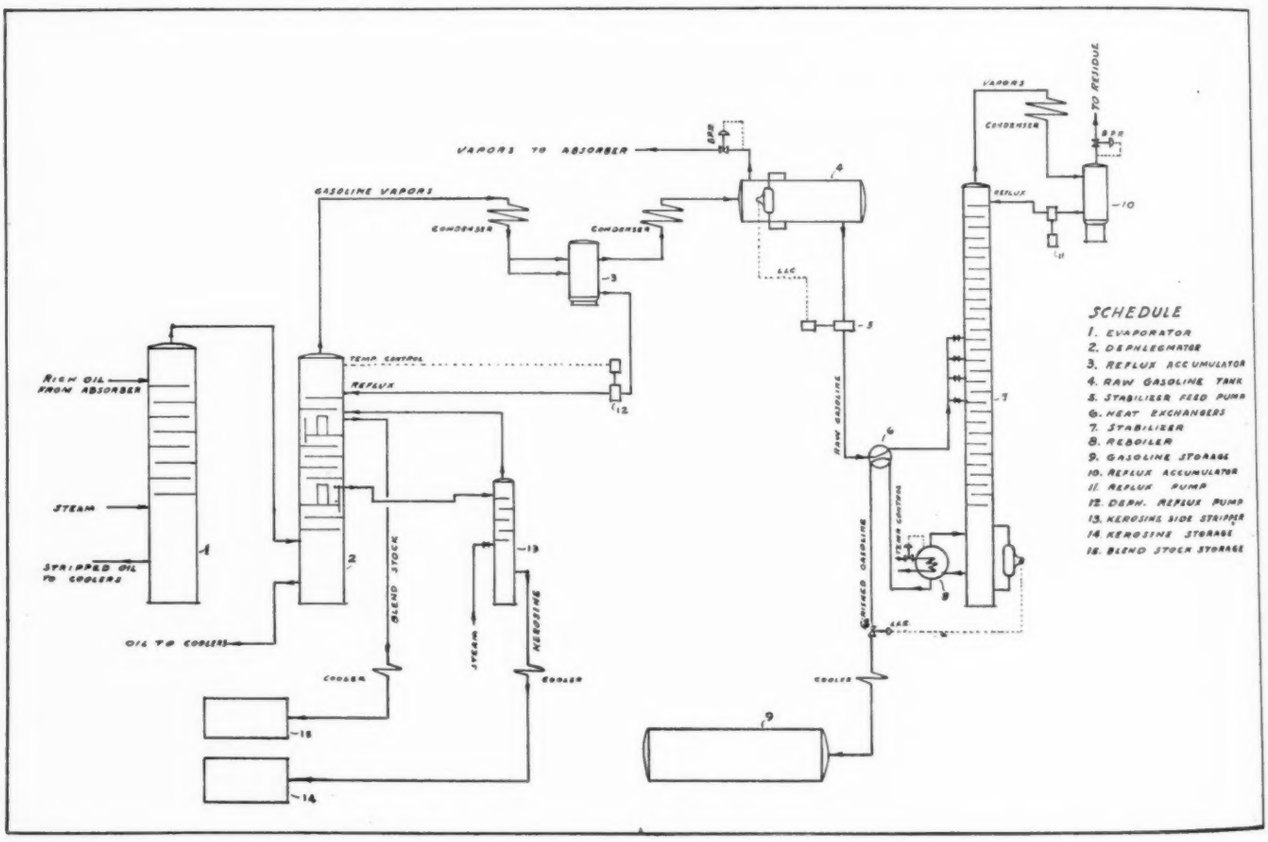
The stabilizer for producing gasoline of specified vapor pressure is a 38-in. diameter, 30-plate unit employing 50-lb. exhaust steam. Surplus reflux from this unit is used in the manufacture of ice for the plant and laboratory.

An essential part of the plant's equipment is the steam power plant. A 3-stage condensate system is employed. Principal equipment consists of four 125-hp. boilers operating at a pressure of 300 lb. per sq. in., provided with superheaters, a feedwater heater, and low- and high-stage condensate tanks. The latter are equipped with liquid level controllers. Feedwater in the first two stages of condensation is pumped by simplex reciprocating pumps. The main boiler-feed pumps are of the outside-packed plunger-type controlled by an excess-pressure governor. Each boiler has four burners operating normally at a pressure of 8 ounces but designed to utilize fuels of varying heat-content without manual adjustment. Because of the quality of the water it has been necessary to provide a continuous blowdown.

Gasoline manufactured by the operation herein described is normally 64 octane. By adding a small amount of tetraethyl lead premium motor fuel can be supplied. When the plant is operating at rated capacity, 45,000 gal. of motor fuel can be manufactured per day.

The plant was constructed on contract by the Western Supply Company. F. C. Hall, general manager of The Agua Dulce Company, supervised the work in behalf of his company.

Flow sheet of vapor cycle of The Aqua Dulce Company plant near Banquette, Texas



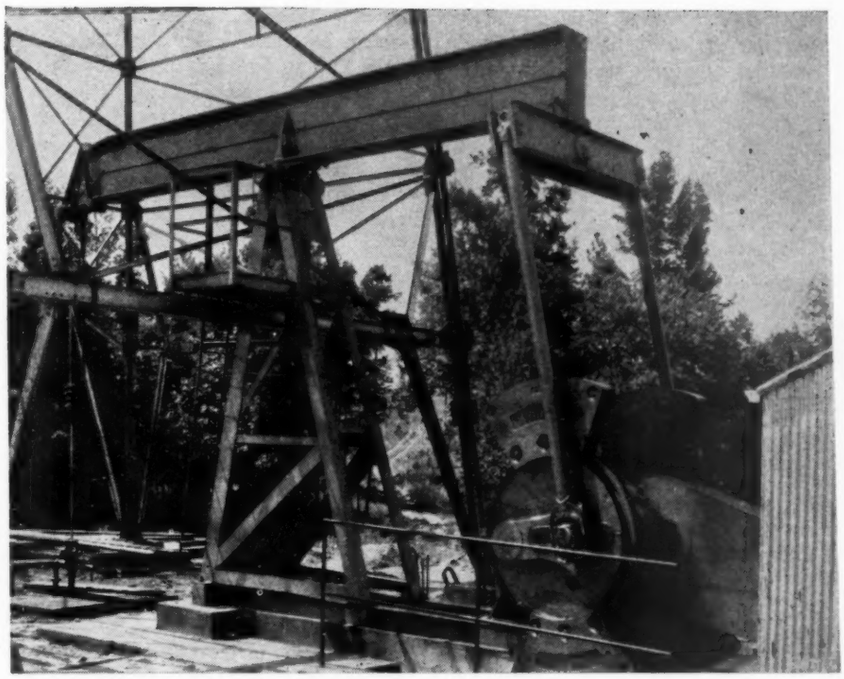


Fig. 4. One type of well-pumping unit used in the Rodessa field

Discussion of surface-controlled gas-lift, pumping methods and equipment, emulsion treating, well servicing, workover and acidizing operations, and salt-water disposal

A PETROLEUM ENGINEER FEATURE

Production Methods in the Rodessa Field

Part 2 (Concluded)

By T. H. GIBBS
District Engineer, Standard Oil Company of Louisiana

Wire-Line-Operated Surface-Controlled Gas-Lift

THE latest type of gas-lift to receive wide acceptance in the field is known as the surface-controlled wire-line-operated type. The equipment consists of a time-cycle-controlled intermitter, a weight cylinder, a gas-turbine-driven wire-line hoist, a wire-line long enough to reach the lower or operating valve, several unloading valves spaced at regular intervals in the tubing, and a standing-valve placed in the tubing string at the packer and immediately below the operating valve. Gas at the required pressure is admitted to the annular space between the tubing and casing. The first unloading valve is opened by forcing the ball valve from its seat by the entry of the weight bar. The valve is held open long enough to transfer any fluid in the annular space to the tubing and then to the surface by gas entering the valve. The weight bar is passed successively through the other unloading valves and the fluid transfer and flow cycle repeated. This process clears the casing and tubing of fluid and provides a reservoir for the operating gas in the annular space. When the operating valve is reached, the weight bar, suspended by the wire line, is placed immediately below the operating valve, and the line is clamped to the weight-cylinder piston rod on the surface. The timing device on the intermitter is then set to admit gas to the weight cylinder, thus raising the weight bar and opening the flow valve at regular intervals, the frequency of which depends upon the fill-up rate in the well.

A biographical sketch and photograph of the author can be found on page 37 of the May issue of *The Petroleum Engineer*, in connection with Part 1 of this article.

At present it is estimated that 30 percent of the wells in the field produce by artificial lift. Of this number, 85 percent produce by gas-lift and 15 percent by pumping.

Beam-Actuated Sucker Rod Pumping

One of the first methods of artificial-lift employed in Rodessa was a pumping unit, installed within the first year of the field's oil-producing life. Several other installations soon followed, as the reservoir pressure was declining rapidly in the closely drilled areas. As strict proration was enforced, however, the pressure decline became more gradual and the flowing and gas-lift periods were correspondingly lengthened. At the present time approximately 15 percent of the wells on artificial-lift now produce by pumping. Most of the beams are driven by gas engines through geared reduction units, and use the rotary-type counterbalance. The gas engines are divided about equally with regard to type, the horizontal single-cylinder being somewhat more common. The vertical twin-cylinder, 2-cycle engine runs a close second in choice. The use of multi-cylinder gas engines in Rodessa has been limited to one type of unit, namely, the air-balanced unit. The range of capacity of the units is slight; most of them are of 25,000-lb. polished-rod capacity. The single- and twin-cylinder gas engines are virtually all of 40-hp. rating, whereas the multi-cylinder type average 60 hp.

A few standard rig fronts have been placed in service but no performance data are available; however, they cannot be expected to equal the heavier and newer unit pumpers. A type of unit employing triple reduction without a gear box is used on several wells. This type employs a V-belt drive for the first reduction and the slower speed

reductions are accomplished by multiple-roller chains.

Another type unit used in Rodessa, offering wide possibilities because of its compactness, portability, and lack of vibration, is the air-balanced unit. Owing to the abovementioned features this unit is unsurpassed for testing, the outstanding feature being the simplicity and accuracy of the counterbalance.

Sucker rods, contrary to usual experience in deep-well pumping, have not been the most troublesome and expensive item. Full strings of 7/8-in. rods are used by most operators; however, in light pumping wells tapered strings of 7/8-in. and 3/4-in. rods are used. In several heavily loaded wells tapered strings of 1-in. and 7/8-in. rods are employed.

Most rod breaks have occurred in the pin, indicating lack of full make-up as a contributing cause, assuming the pin box shoulders to be properly machined. In the choice of rods, regardless of make, the same properties are usually sought; namely, a steel of great shock and fatigue resistance, ductility, toughness, and resistance to corrosion.

Sucker Rod Pumps

The two basic types of rod-actuated pumps are used in Rodessa. The use of a greater number of rod-insert-type pumps is due to a number of factors, the foremost being lighter loading of rods and surface equipment by use of smaller plungers, and reduced repair costs, as these pumps can be removed for inspection and repair without the expense and attendant downtime of a tubing job. The insert-type pump is further divided into two classes, traveling plunger and traveling barrel, and these classes are about equally popular among the operators, despite the fact that the reciprocating-barrel pump was originally designed to combat sand accumulation.

The choice of pump hold-down is also divided about equally between the anchor type and the top-lock hold-down.

Large-capacity tubing pumps (the type in which the barrel is run as part of the tubing string) are used in several wells producing large amounts of fluid from relatively high pumping levels.

Most of the pumping wells are equipped with 2½-in., 6.5-lb. external-upset, seamless steel tubing, though some variance has been noted in grade. Most of the strings are Grade "C" but there are a few full strings of Grade "D". Some operators are now substituting Grade "D" for "C" in the upper portion of the string in an effort to combat heavier loading of the tubing as pumping levels decrease, occasioning increased impulse or transfer loads. Tubing travel resulting from the abovementioned effect has without doubt been the greatest obstacle to successful pumping in the field, as both casing and tubing have been damaged to the point of failure in several wells, resulting in several expensive repair jobs.

Salt has been known to clog the face of the producing formation and in extreme cases will partly fill the well bore. The deposition is a slow process and is thought by some operators to result from connate water entering the well with the gas and leaving as water vapor with the gas, depositing the salt crystals as a precipitate.

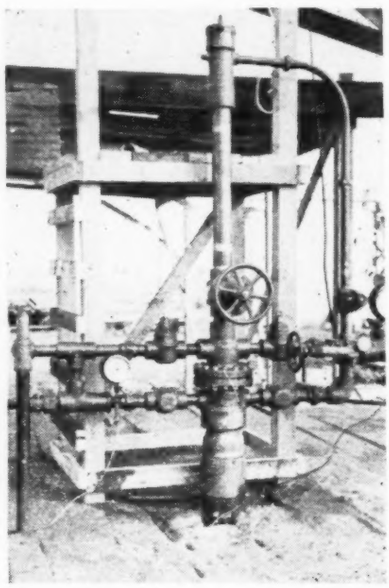


Fig. 5. A 3-in. plunger-lift installation

Hydraulic Pumping

The first installation of a hydraulic pumping unit in Rodessa was made in September, 1938. The test well was located on the Texas side of the field and produced from the Young-Dees zone. The productivity of the well was determined to be 130 bbl. of fluid per day, of which 30 percent was water. The corrosiveness of the water offered a serious obstacle. Exhaustive tests now being made by the manufacturers and operators should prove or disprove the suitability of this method of production for wells in Rodessa producing water.

Two installations on the Louisiana side of the field in wells of low productivity have been successful. Both are producing from the Gloyd section, a gas-drive reservoir where no water trouble is anticipated.

The method undoubtedly offers wide possibilities and has proved practicable in other fields, but tests now in progress must be completed before any definite conclusion can be drawn for Rodessa.

A brief description of the method and equipment used in this type of operation follows:

Equipment necessary for hydraulic pumping consists of a pump-and-engine unit that is lowered into the well and a hydraulic power unit installed at the surface. The subsurface unit comprises a double-acting reciprocating plunger pump directly connected to and operated by a fluid engine. This unit is run inside the regular producing string of tubing, which is equipped with a gas anchor at the bottom and a seating device for the pump within the gas anchor. The pump is run on a string of smaller tubing (usually 1¼-in. if the producing string is 2½-in.), called the power or pressure tubing. The fluid engine actuating the pump is driven by clean oil pumped down the power tubing, the exhaust being returned to the surface through the annular space between the power and production tubing strings with the oil produced by the well.

The hydraulic power unit at the surface supplying the operating fluid under pressure consists of a unitized triplex power pump adapted for either electric or gas-engine drive. The manufacturer also supplies a filter system integral with the surface unit; however, the filter has not been used in Rodessa as the oil does not contain an abrasive.

Actual capacity of the 2½-in. unit is 150 bbl. per day. In wells of low fluid level or wells that can be pumped-off, an orifice-type governing device is installed immediately above the pump. The governor insures a constant rate of flow and thereby prevents racing the pump.

In concluding this discussion of methods of artificial-lift, it can be said that no doubt there are areas in the field that can be produced to economic depletion only by pumping, as well as areas where gas-lift will be found practicable in reaching the economic limit.

Emulsion Treating

The method used in treating emulsions depends on the volume of fluid to be treated. The most popular methods are: settling tanks and heat, settling tanks and chemical without heat, and chemical treatment without the use of heat or settling tanks. It is necessary at times to combine heat, skimming, and chemical methods to meet unusual

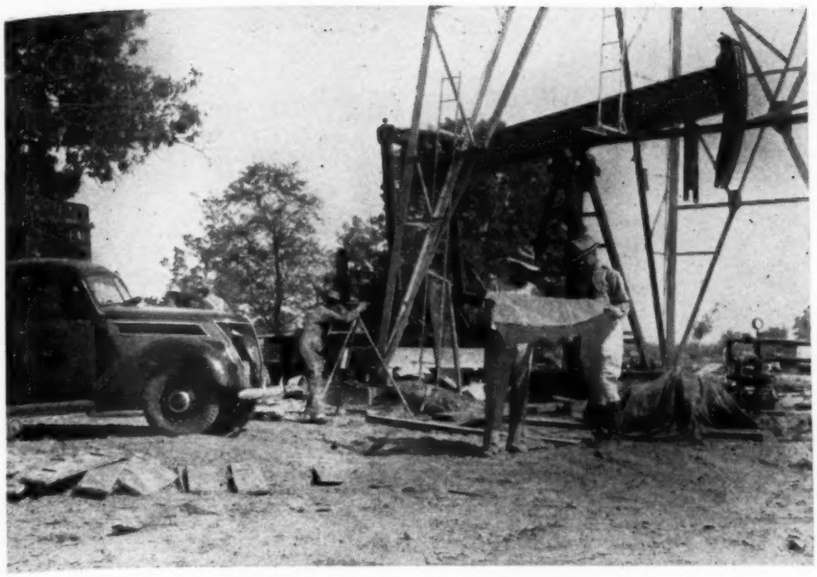


Fig. 6. Installing a large twin-crank pumping unit

problems. Most leases that include wells producing from the Young-Dees zone are equipped with siphon-drained settling tanks at the tank battery. The inside flume formerly held first place in operators' choice; most newer installations are equipped with the outside type flume.

In comparison to the problem encountered in many other fields, treating of emulsions in Rodessa has been and will probably continue to be an easy task.

Well Servicing

Well servicing is becoming of increased importance in production operations. The natural decline in the number of flowing wells has increased the demand for servicing equipment in Rodessa.

The relatively great depth of the wells necessitates maximum strength and speed, whereas wide spacing and scattered lease holdings make portability essential. As a result the most efficient pulling machine unit in Rodessa consists of a single-drum winch equipped with a $5\frac{5}{16}$-in. driveshaft, $3\frac{1}{2}$-in. countershaft and $3\frac{3}{16}$-in. jackshaft operating at a line speed of 1750 ft. per min. in high gear, and having a pulling capacity of about 30,000 lb. in the first speed. This unit is powered by a 110-hp. gasoline motor driving through a three- or four-speed transmission and a two-speed jackshaft, all mounted on a 7-ton truck. (Note: the shaft diameters listed are the diameters at the point of greatest strain).

Workover Operations

A complete discussion of the history of Rodessa workover operations would entail a lengthy article, so only a brief summary of types will be included.

Many attempts have been made to exclude bottom water or edge water without appreciable success. The squeeze job has been the method most often used and in only a few wells has it been satisfactory. Apparently the permeability of the limestone is not great enough to admit the cement. In operations actually witnessed, where it was first thought that some cement had penetrated the formation, checking the weight of the cement slurry at the surface against its probable weight at the face of the formation indicated that some change in volume resulted from squeezing water from the cement slurry into the formation. Laboratory tests have proved that changes in volume as great as 30 percent can result from squeezing water from the cement mixture, depending on the water/cement ratio.

The dump-bailer method of cementing bottom plugs has also been used in the field. This method has been successful only in plugging the entire formation when it is desired to produce a higher zone.

Semi-squeeze cementing, or introduction of the cement into the well bore through tubing without use of a retainer, reverse circulation being depended upon to clean the tubing and determine the top of the cement plug, is preferred by some operators. This method includes applications of hydraulic pressure to the cement plug, either alone or combined with gas pressure after the tubing has been raised a safe distance above the top of the plug.

Workover and Acidizing Operations

The use of acid has played an important production role in Rodessa as an aid to completion of wells and maintenance of production. The range of porosity and permeability throughout the field is great. It would be impossible to estimate the oil recovered as a result of acidizing. All the recovered oil produced from acidized wells cannot be credited to this operation. Recovery rates have been increased and profitable operation prolonged, and some wells now producing were completed as commercial producers only after acidizing.

Acid is used extensively in workover and cleanout operations because the drilling mud with which the wells were drilled contains large quantities of limestone. Use of acid has been found to be the simplest and most economical means of breaking the mud sheath, as the mud cake is almost impervious to water after having been exposed to the reservoir temperature of 189°.

The customary "Two Pump" oil-flush acidizing procedure has been altered in order to minimize the loading of the low-pressure oil-producing area in the Gloyd reservoir. The first departure from the regular procedure consisted merely of introducing gas from a high-pressure gas-lift system into the oil used to force the acid into the formation. Further decline of reservoir pressure soon prohibited the use of oil altogether, as it became necessary to swab the wells to restore production. Gas injection eliminates the use of oil to fill the annular space and serves to lighten the small amount of oil used to flush the acid. The pressure exerted by the gas forces the acid into the formation, if force is needed, without killing the natural pressure of the reservoir as a liquid would tend to do.

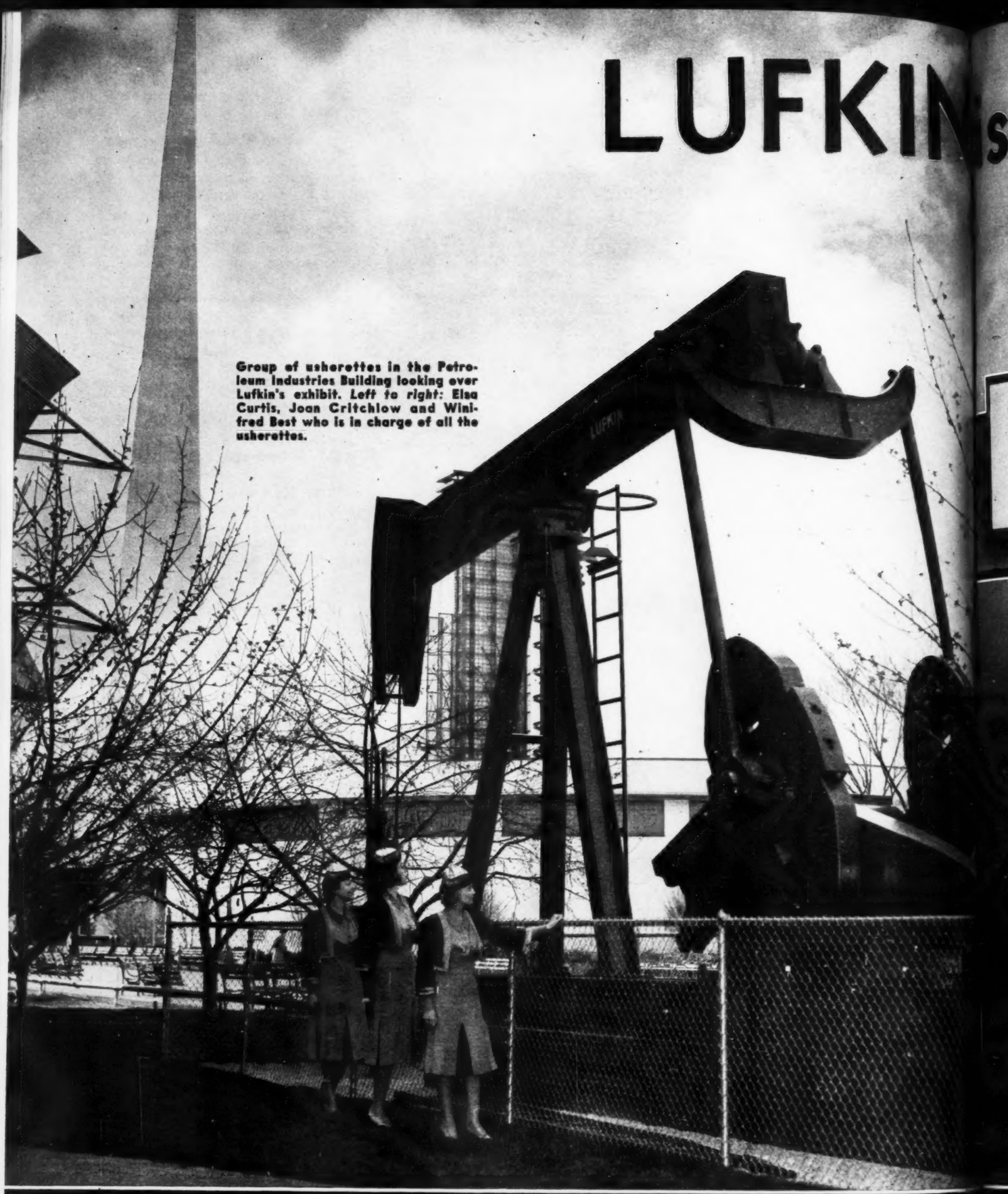
No difficulty has been experienced in restoring flow in wells treated in this manner.

In addition to the reduction in expense resulting from elimination of swabbing and its attendant delay in normal production, relatively greater initial flow has been obtained from the wells gas-treated in the above manner than from similar wells acid-treated in the usual manner, using oil as a flushing agent.

The method is available to any operator in the field, and a supply of high-pressure gas is not necessary as one acid-treating company maintains a large-capacity high-pressure portable compressor for such work.

High-pressure gas for gas-lift operation may be obtained by compression

(Continued on Page 40)



Group of usherettes in the Petroleum Industries Building looking over Lufkin's exhibit. *Left to right:* Elsa Curtis, Joan Critchlow and Winifred Best who is in charge of all the usherettes.

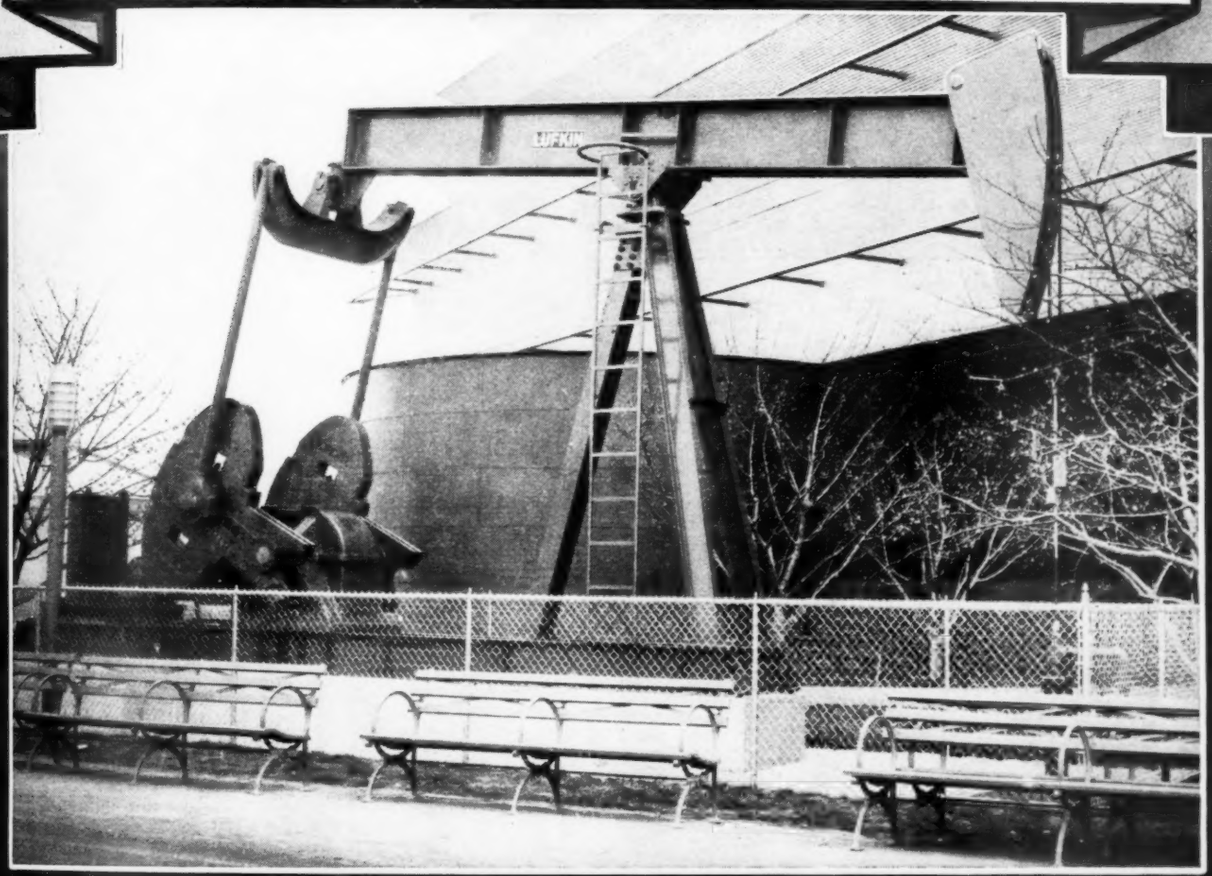
s very much . . .

"At the Fair"

A Hearty Invitation

TO VISIT THE

LUFKIN EXHIBIT • New York World's Fair • Petroleum Bldg.



PUMPING UNITS

LUFKIN UNITS ARE MANUFACTURED IN LUFKIN, TEXAS, BY
THE LUFKIN FOUNDRY & MACHINE COMPANY, BRANCHES IN PRINCIPAL OIL CENTERS

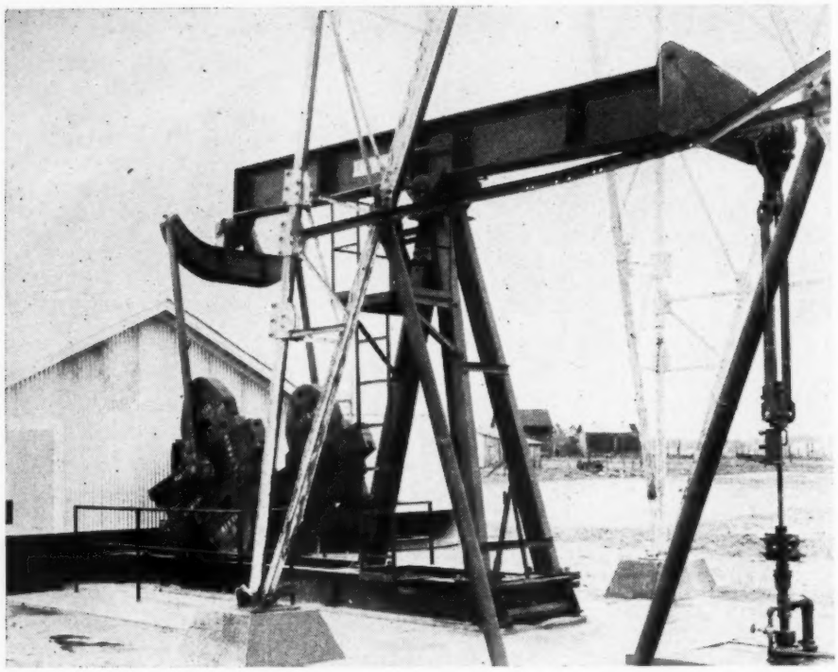


Fig. 7. Another type of pumping unit used extensively in the Rodessa field.

(Continued from Page 37)

or directly from high-pressure gas wells. Compressed gas is employed in the most extensive gas-lift system in the field. Most operators, because of the low price and availability of high-pressure gas from an upper gas sand, and because of the capital investment required to install compressor equipment, prefer to use gas from gas wells.

The usefulness of this gas has resulted in many depleted wells being plugged-back and gun-perforated in the gas-producing zone. In the past it has been necessary to set a cement retainer and squeeze cement against the exposed formation to insure a successful plug-back.

Recent plug-back operations have been completed at a saving of time and expense by use of a cable-controlled bridging plug. The plug is run instead of a perforating gun by one of the regular gun-perforator service units. When the plug has been lowered to the desired depth, a small charge of powder in the plug is electrically ignited by the operator of the service unit. The charge fractures an easily broken clevis, releasing a spring that causes the two-way slips to set and expand the packing sleeve. The firing also releases the setting head, attached to the cable from the plug. Although the packing element is synthetic rubber, cement is usually dumped on top of the plug to guard against the deteriorating effect of oil and gas upon the packing sleeve.

Gun-perforating has been extensively employed in completion and workover operation. Its use has not been limited to straight gun-perforating of a known oil- or gas-producing zone. The service has been used in water shut-off attempts, both as a means of testing and to provide entry into the formation for the cement. Shooting has been done in open hole when the face of the formation was thought to be clogged.

Circulation has been established in several stuck strings of casing only after gun-perforating in combination with acid treatment had been employed.

As operating problems increase, doubtless other uses for gun-perforating will be found. Only those actually employed in this field are here recorded.

Salt-Water Disposal

Salt water in the Rodessa field is being disposed of by several methods; evaporation from surface pits was the method first attempted. During the winter season it is often necessary to aid natural evaporation by applying gas flames from jets installed in the pits.

Several operators, anticipating water production beyond the capacity of evaporating pits, have solved the problem by drilling disposal wells and injecting the water into a sand at medium depth. Some trouble has been experienced in the operation, that most often encountered being the plugging of the face of the formation by minerals precipitated from the water. One input well was cleaned by admitting high-pressure gas to the formation and then suddenly releasing it. The differential pressure thus applied to the face of the sand was sufficient to free it of the clogging material. The well was sand-pumped before injection was resumed. Input pressures range from vacuum to 500 lb., depending upon the filtering efficiency and cleanliness of the injection well. Gathering lines are made of an asbestos-cement composition of maximum resistance to corrosion.

Increased Gasoline Recovery Results from Lowering Separator Pressure by the Use of Vacuum Traps or Blowcases

One operator uses vacuum traps or blowcases to transfer oil from the separator to stock tanks, thereby relieving the separator of the pressure required for displacement. It is estimated, based on results of gasoline recovery tests, that a reduction in the pressure on the separator from 20 or 30 lb. per sq. in. to 5 lb. per sq. in. has increased the gasoline recovery 50 to 100 percent. Another means of producing more gasoline entails elevating the separators; however, the labor and material involved, the loss of production during the change, and the disadvantage of increasing the back pressure on the wells favor the use of blowcases.

The equipment consists of a horizontal cylindrical tank containing an internal float that actuates, through a ball-bearing stuffing box, a snap-acting pilot on the float housing. The snap-acting pilot mechanism is so arranged that, when the float is in a low position, there is no pressure upon the diaphragm of the diaphragm-actuated spring-controlled three-way valve that governs the admission and exhaust of the low-pressure residue gas used to displace the fluid from the case to the stock tanks.

For controlling the flow of fluid draining from the separator to the case and also for controlling the discharge of oil from the case to the stock tank, two swing check valves are used. The check valve placed on the line between the separator and case allows flow only from the separator to the case and closes when the pressure is applied to the case, preventing return of fluid to the separator.

The check valve placed on the discharge line from the case to the stock tank permits the discharge of oil from the case into the tanks only when pressure is applied to the blowcase. The vacuum traps are equipped with pop valves to relieve the shells of pressure beyond the safe working limit of the vessels.

INTERNATIONAL HARVESTER

sells MORE HEAVY-DUTY TRUCKS (2-ton and up) *than any other* THREE MANUFACTURERS COMBINED

IN ever-increasing numbers, truck users are investing in the truck that bears the Triple-Diamond mark. They are *cashing in* on the *high-quality standard* maintained for International Trucks during thirty-two years of truck manufacture . . . a quality standard of which every man in the Harvester organization is proud.

Another practical reason for the great demand for International Trucks is the fact that they are backed by the *most complete Company-owned truck service organization.* Whatever your own hauling need, the International dealer or branch near you has the truck for it. Sizes range from ½-ton light-delivery trucks to big 6-wheelers.

INTERNATIONAL HARVESTER COMPANY
(INCORPORATED)
180 North Michigan Avenue Chicago, Illinois

INTERNATIONAL TRUCKS

Calculation of Transfer Area in Heat Exchangers

PART 1

Method of graphical integration using simplified formulae aids in more accurate design of tubular exchangers

By JOHN GRISWOLD
Assistant Professor of Chemical Engineering, University of Texas

THE basic equation for the rate of heat flow from one fluid to another through the wall of a tube is:

$$dq = A\,U\,d(T - t)$$

in which:

q = the time rate of heat transfer.

U = the overall heat transfer coefficient.

A = the heat transfer surface area.

T, t = the temperatures on opposite sides of the tube at any point.

d(T — t) is also designated as Δt, or Δ.

To determine accurately the surface area required in a heat exchanger, it is necessary to integrate the equation

$$q = A \int_{(T-t)_1}^{(T-t)_2} U\,d(T - t).$$

The procedure used almost universally is to adopt average values for U and Δ:

$$q = A\,U_{av.}\,\Delta_{av.}$$

The accuracy of this method is doubtful unless the mean values are ascertained carefully. Values of U and Δ often vary so much in a given exchanger that the use of arithmetic averages may result in serious error. Because the determination of averages is an important part of exchanger design, this review and discussion of various methods of averaging should prove valuable to the design engineer. Particular attention will be given to the design of exchangers for heating or cooling viscous liquid because the solution of this problem is usually the most susceptible to error.

JOHN GRISWOLD

received degrees in chemical engineering from the University of Illinois and the Massachusetts Institute of Technology, after which he was employed by The Pure Oil Company as resident chemist at its Muskogee, Oklahoma, refinery, and as development engineer at the same company's Northfield, Illinois, laboratories—Has been teaching chemical engineering at the University of Texas since the fall of 1936 and doing research work on problems encountered in petroleum refining.

General Relations Used in Solving Heat Transfer Problems

Using the nomenclature of McAdams and Gilliland[1], the overall heat transfer coefficient for a heat exchanger is the summation of the tube-wall, scale, and two fluid-film conductances, all calculated to a common basis that is usually the inside area of the tubes. The areas appear as ratios, and so, for the same length of tube, are equivalent to diameter ratios:

$$1/U_i = r_{tube} + r_{scale} + r_o + r_i$$
$$= 1/(hA)_{tube} + 1/(hA)_{scale} + 1/(hA)_o + 1/(hA)_i$$
$$= \frac{L\,D_i}{k\,D_{av.}} + \frac{D_i}{h_s D_o} + \frac{D_i}{h_o D_o} + \frac{1}{h_i} \quad . \quad (1)$$

During the last decade, a great deal of successful work has been done in correlating heat transfer coefficients through fluid-films with the properties of the fluid, its mass velocity, and the dimensions of the equipment. The correlations were made in the form of power functions of dimensionless groups; the Reynolds Number, the Nusselt Number, the Prandtl Number, and the Grashof Number, which collectively include all the variables affecting heat transmission by convection. The technique used to obtain data for these correlations was to operate experimental equipment over very narrow temperature ranges so that the error in the arithmetic average temperature would be slight. The resulting correlations aid in a quite accurate prediction of the fluid-film coefficient of heat transfer (h) but h is constant only for isothermal or point conditions. As the temperature of the fluid must change as it passes through an exchanger the correct solution of a problem must depend upon the accuracy of selecting the temperature or temperatures upon which h is based.

Nature of Fluid. Film coefficients of gases change their values quite slowly with variations in temperature. It is sufficiently accurate usually to evaluate h at the arithmetic average of the temperatures of the gas entering and leaving the exchanger.

When both inside and outside film

[1]By Walker, Lewis, McAdams, and Gilliland, *Principles of Chemical Engineering*, p. 143. McGraw-Hill Book Company, New York, N. Y. (1937).

ONE-PUTTERS

HIT THE HOLE THE FIRST TIME ON WORKOVER JOBS, TOO

IT costs more to pump water than to pump oil . . . and getting rid of the water is an expensive nuisance, too. That's why a good workover job pays for itself in no time. But be sure to hit the hole the first time . . . by using the right cement . . . 'Starcor'.

'Starcor' gives you a free-flowing slurry . . . low viscosity means easier to pump. And a 'Starcor' slurry stays liquid till the job is done, then gets hard fast. Results: scores of workover jobs successfully completed with 'Starcor' . . . without a cement failure.

Use 'Starcor'* for squeeze jobs, and for deep wells, high temperatures, and extra sulphate resistance . . . 'Incor'* for wells of moderate depth and low temperatures . . . Lone Star for work above-ground. Portland cements, all—each the quality leader in its own field. Backed by Lone Star's quality record for over a quarter century.

*Reg. U. S. Pat. Off.

TWO PORTLAND CEMENTS— BOTH MADE FOR OIL WELLS

USE 'STARCOR'—for deep wells, high temperatures, extra sulphate resistance.

USE 'INCOR'—for wells of moderate depth, and low temperatures.

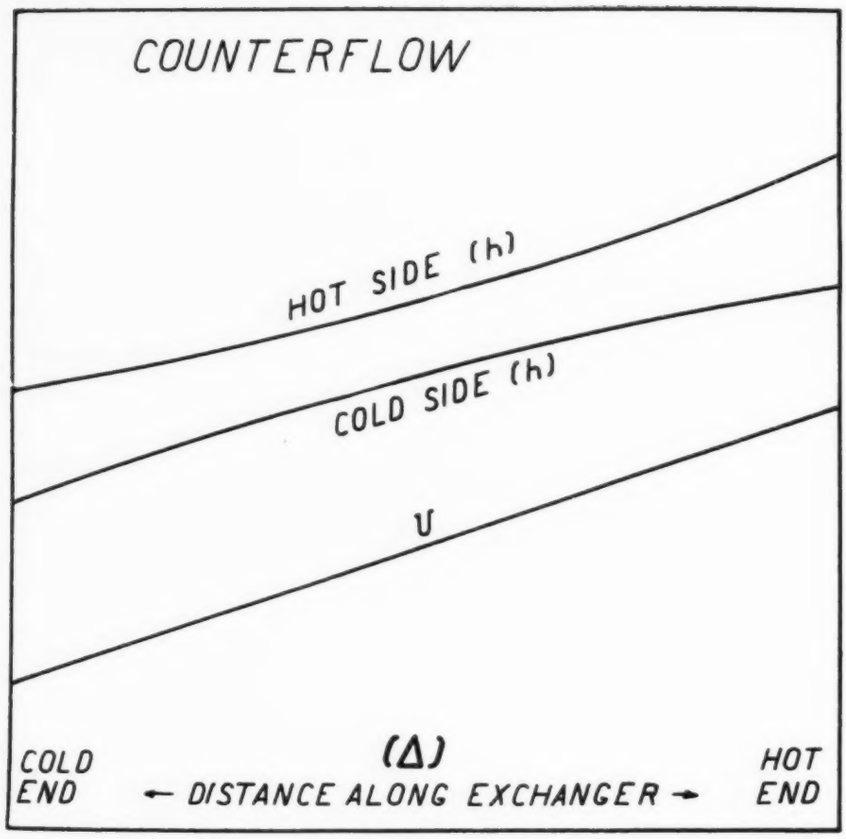


Fig. 1

coefficients are constant or nearly constant, the correct temperature difference to apply to both parallel and counterflow equipment is the logarithmic mean:

$$\Delta_{av} = \frac{\Delta_1 - \Delta_2}{2.3 \log \left[\frac{\Delta_1}{\Delta_2}\right]} \quad . \quad . \quad . \quad (2)$$

NOTE: The logarithm to the base 10 may be converted, as here, to base e by multiplying by 2.3.

Non-viscous liquids such as water, naphtha, and some organic solvents also show a change in film coefficient values as the temperature varies. In the absence of boiling, however, h will not change materially. An approximation that is generally satisfactory is to assume that values of h and U vary directly (are linear) with the liquid temperature. On this assumption, Colburn[2] has derived the important relation that the true mean value of $(U\Delta)$ is the logarithmic mean between the values at the terminal temperatures of the equipment:

$$(U\Delta)_{mean} = \frac{(U_1\Delta_2) - (U_2\Delta_1)}{2.3 \log \left[\frac{U_1\Delta_2}{U_2\Delta_1}\right]} \quad (3)$$

Viscous liquids often present a more complicated problem in averaging, as the film coefficient value increases directly as temperature increases at a rate dependent upon the inverse-power function of viscosity. In general, the greater the magnitude of the viscosity, the more rapidly will the film coefficient change per unit of temperature change.

Typical Cases for Viscous Liquids

There are three* important cases involving viscous liquids to be considered:

(1) Counterflow heat exchangers having viscous liquids on both sides of the tubes.

(Continued on Page 48)

*To preserve clarity and coherence, the case of multi-pass heat exchangers has been omitted.

[2]Colburn, A.P. *Ind. Eng. Chem.*, 25, 873, (1933).

Nomenclature

NOTE: All units are based on English units unless otherwise designated.

A = area of heat transfer surface, sq. ft.
a, b = specific exponential constants for liquid to be heated.
C = heat capacity, B.t.u./lb., °F.
D = diameter, ft.
G = mass velocity, lb./hr-sq. ft. $= V\rho$.
h = film coefficient of heat transfer, B.t.u./hr-sq. ft., °F.
k = thermal conductivity, B.t.u./hr-sq. ft., °F., ft.
L = thickness of tube-wall, ft.
N = heated length of tube, ft.
q = rate of heat flow, B.t.u./hr.
r = summation of thermal resistance:

$$= \frac{LD_i}{k\,D_{av}} + \frac{D_i}{h_0 D_0} + \frac{D_i}{h_s D_0}$$

Re = Reynold's Number $= \frac{DG}{\mu} = \frac{DV\rho}{\mu}$ (dimensionless).

t = temperature of liquid to be heated, °F.
T = temperature of heating medium, °F.
U = overall coefficient of heat transfer, B.t.u./hr-sq. ft., °F.
V = average linear velocity of liquid, ft. per hr.
W = weight rate of flow of liquid, lb. per hr.
w = weight rate of flow of liquid per tube, lb. per hr.

Greek Letters

α, β = specific constants for simplified coördinates of Fig. 4.
Δ = temperature difference, $(T - t)$, Fahrenheit degrees.
γ = specific constant from equation in (h) and (μ).
μ = viscosity of liquid, lb./hr-ft. = 2.42 × viscosity in centipoises.
ρ = density of liquid, lb./cu. ft.

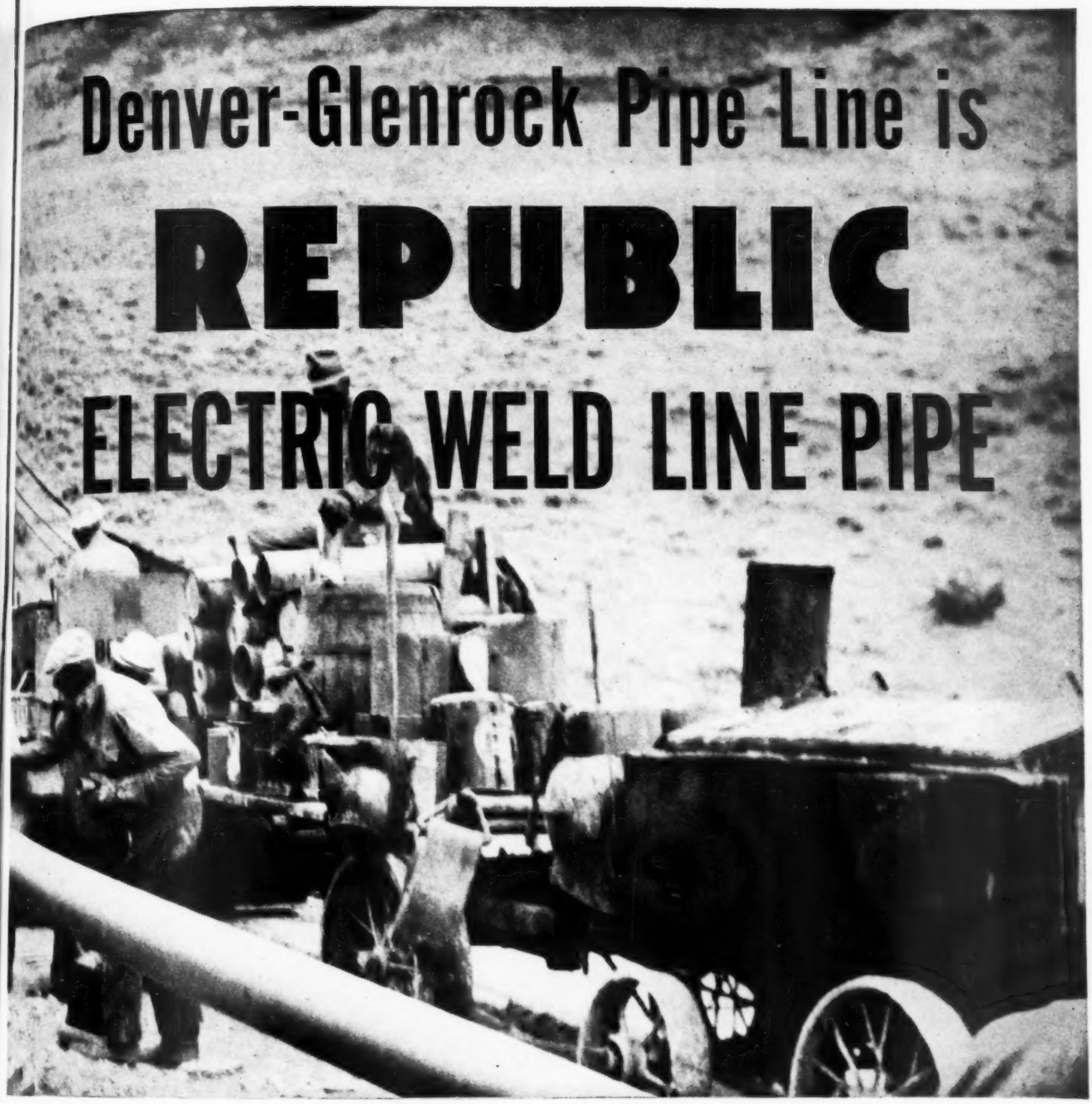
Subscripts

1, 2 = properties of liquid at entrance temperature, and outlet temperature, respectively.
f = properties of liquid-film, taken at avg. of tube-wall and liquid temperatures, $t_f = \frac{t_w + t}{2}$.
i = quantities based on inside area of tubes.
o = quantities based on outside area of tubes.
tb = quantities in zone of turbulent flow.
tr = quantities in zone of transitional flow.
vi = quantities in zone of viscous flow.
w = properties of liquid at wall temperature.

Denver-Glenrock Pipe Line is

REPUBLIC

ELECTRIC WELD LINE PIPE



that do much to speed construction are—long lengths—straightness—perfect roundness—uniform wall thickness—low-carbon weldability—ductility for easy bending—an electric resistance weld that tests stronger than the pipe wall itself.

Thousands of miles of Republic Electric Weld Line Pipe installed here and abroad testify to the ability of this universally-accepted line pipe to meet every test of construction and service.

REPUBLIC STEEL CORPORATION
GENERAL OFFICES: CLEVELAND, OHIO

UNION DRAWN STEEL DIVISION
BERGER MANUFACTURING DIVISION
NILES STEEL PRODUCTS DIVISION
TRUSCON STEEL COMPANY
STEEL AND TUBES, INC.

REG. U.S. PAT. OFF.
REPUBLIC
STEEL

PIPE

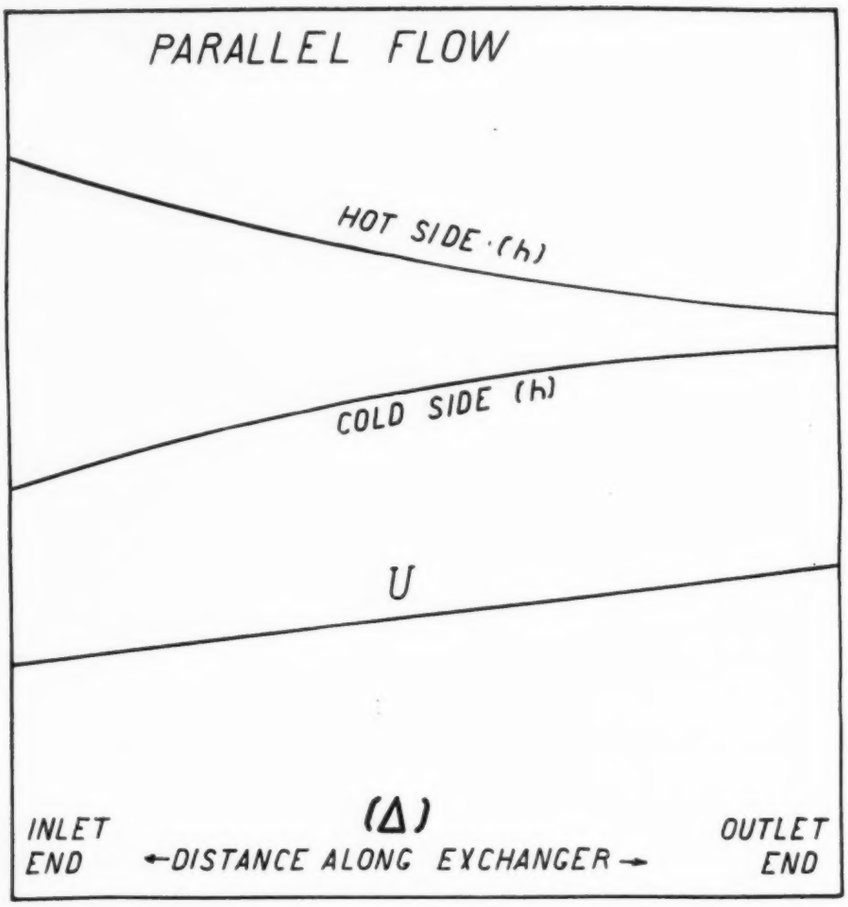


Fig. 2

Case (3) is more involved. Heaters are frequently employed using steam at constant temperature, or water heated within fairly narrow temperature limits. As the steam or water film coefficient is much higher than that of the viscous liquid inside the tubes and does not change greatly, an average value of h_o may be selected and treated as a constant. Equation (1) then reduces to:

$$1/U_i = r_{(\text{tube wall} + \text{scale} + \text{outside film})} + 1/h_i \quad . \quad . \quad . \quad . \quad . \quad (1a)$$

Under the conditions of Case (3), U_i is not linear with either t or Δ. Fig. 3 shows the qualitative variation of h_i, U_i, and Δ over the length of the apparatus and for all ranges of flow rates. Colburn solves a problem involving Case (3) by using a temperature correction [the derivation of which is similar to that of Equation (3)] added to t_i. The use of Equation (3) for designing viscous-oil heaters indicates too large an area. The application of Colburn's correction may lead to the use of an area slightly smaller than is required.

EDITOR'S NOTE: The concluding installment of this discussion will be published in an early issue.

(Continued from Page 44)

(2) Parallel-flow exchangers having viscous liquids on both sides of the tubes.

(3) Heaters or coolers having a viscous liquid inside the tubes and steam or water outside the tubes.

Colburn[2] concludes that often cases (1) and (2) result in an overall heat transfer coefficient varying almost directly with temperature or temperature difference, although this is not true of the individual film coefficients. Figs. 1 and 2 illustrate this qualitatively. The graphs of the film coefficients plotted against Δ taken progressively along the exchanger are curves. The curves representing the two films are approximately symmetrical opposites. When added according to Equation (1) they result in an expression for U versus Δ that is either a straight line or a curve having a slight "S" shape. As Equation (3) was derived on the assumption of a linear relation between U and Δ, it is applicable to these two cases.

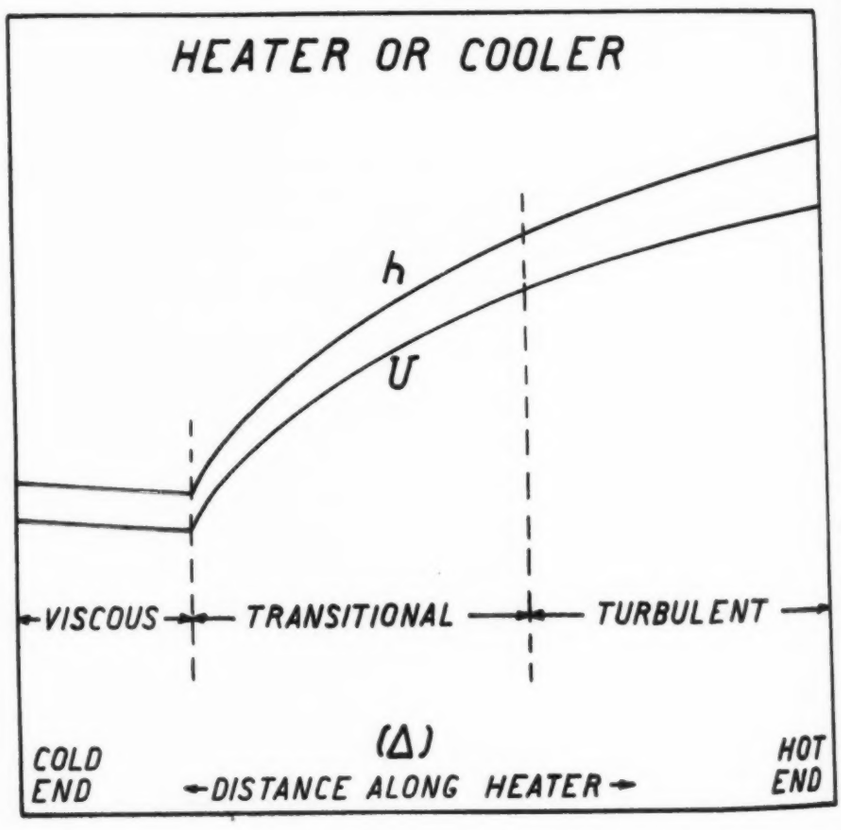


Fig. 3

THE *Petroleum* Engineer's CONTINUOUS TABLES

A DAILY REFERENCE FOR OPERATING MEN

INSTALLMENT No. 24

INDEX TO TABLES*

Title of Table		*Index No.*	*Page*	*Issue*
Conversion factors		P 066.000	249	Oct.
Flange bolt and gasket sizes	(sheet 1)	P 094.111.2	57	Apr.
Flange bolt and gasket sizes	(sheet 2)	P 094.111.2	63	Apr.
Diameter of wire of various gauges		P 094.14	133	June (1938)
Belt speed	(sheet 2)	P 094.603.1	145	Nov.
Lubricants for roller-type bearings		P 094.710	59	May
Piston speed, ft. per hr.	(sheet 1)	P 094.805	59	Apr.
Piston speed, ft. per hr.	(sheet 2)	P 094.805	55	May
Boiler fuel gas consumption		P 094.818.11	63	Mar.
Capacity of burner orifices, cu. ft. per hour, sp. gr. of gas .55	(sheet 1)	P 094.818.111	65	June (1939)
Capacity of burner orifices, cu. ft. per hour, sp. gr. of gas .55	(sheet 2)	P 094.818.111	61	June (1939)
Current taken by electric motors		P 094.839	129	Sept.
Theoretical capacity of reciprocating pumps	(sheet 3)	P 094.865.1	83	July
Specific gravity corresponding to A.P.I. gravity	(sheet 1)	P 213.1	57	June (1939)
Pressure drop (lb. per sq. in. per 1000 ft.) in water lines		P 421.4	59	June (1939)
Capacity of wide drum of large A.P.I. standard sand reel, ft. of line		P 422.143.152	57	May
Dimensional specifications of cable drilling tool joints		P 424.22	107	Aug.
Weight of A.P.I. standard drill pipe		P 425.215	61	Mar.
Capacity of mud pit, cu. ft. per in. depth	(sheet 1)	P 425.218.21	61	May
Capacity of mud pit, cu. ft. per in. depth	(sheet 2)	P 425.218.21	63	May
Weight and displacement of 2⅜-in. drill pipe		P 425.240.237	127	Sept.
Weight and displacement of 4½-in. drill pipe		P 425.240.450	123	June (1938)
Weight and displacement of 5 $\frac{11}{16}$-in. drill pipe		P 425.240.556	127	June (1938)
Weight and displacement of 6⅝-in. drill pipe		P 425.240.662	111	Aug.
Weight and displacement of 7⅞-in. and 8⅝-in. drill pipe		P 425.240.787	115	Aug.
Clearance between tool joints and wall of well		P 425.294.252	139	Nov.
Composition and properties of cement slurries		P 444.1	57	Mar.
Total upward pressure between drill pipe and casing	(sheet 3)	P 448.425	129	June (1938)
Total upward pressure between drill pipe and casing	(sheet 4)	P 448.425	79	July
Total upward pressure between casings	(sheet 1)	P 448.430	131	Sept.
Total upward pressure between casings	(sheet 2)	P 448.430	123	Sept.
Total upward pressure between casings	(sheet 3)	P 448.430	143	Nov.
Total upward pressure between casings	(sheet 4)	P 448.430	71	Jan.
Total upward pressure between tubing and casing	(sheet 1)	P 448.456	77	Jan.
Total upward pressure between tubing and casing	(sheet 2)	P 448.456	79	Jan.
Total upward pressure between tubing and casing	(sheet 3)	P 448.456	85	Feb.
Total upward pressure between tubing and casing	(sheet 4)	P 448.456	89	Feb.
Horsepower required to compress natural gas	(sheet 1)	P 515.5	131	June (1938)
Horsepower required to compress natural gas	(sheet 2)	P 515.5	87	Feb.
Energy required to lift fluid	(sheet 1)	P 519.5	81	July
Energy required to lift fluid	(sheet 2)	P 519.5	121	Sept.
Energy required to lift fluid	(sheet 3)	P 519.5	137	Nov.
Velocity of flow through 1¼-in. tubing		P 533.300.125	125	Sept.
Velocity of flow through 1½-in. tubing		P 533.300.15	117	Aug.
Velocity of flow through 4-in. tubing		P 533.300.4	135	June (1938)
Volume of liquid contained in tubing strings, gal. and bbl.		P 535.131	55	June (1939)
Pressure of input water at sand face	(sheet 2)	P 538.066	61	Apr.
Pressure drop per mile of 8-in. pipe line, oil of 30° A.P.I.		P 615.108.30	125	June (1938)
Pressure drop per mile of 10-in. pipe line, oil of 30° A.P.I.		P 615.110.30	109	Aug.
Temperature-specific gravity multipliers, Weymouth's formula	(sheet A)	P 621.100.1	245	Oct.
Diameter-length multipliers, Weymouth's formula	(sheet B)	P 621.100.1	141	Nov.
Capacity of bolted tanks	(sheet 2)	P 644.200.1	113	Aug.

Engineering Data Especially Compiled for Office, Field, and Plant Use
A REGULAR FEATURE OF THE PETROLEUM ENGINEER

Title of Table		*Index No.*	*Page*	*Issue*
Capacity of bolted tanks	(sheet 3)	P 644.200.1	119	Aug.
Natural gas flow—critical velocity, ratio of specific heats, specific volume, etc.	(sheet 1)	P 681.3	63	June (1939)
Volatility of hydrocarbons relative to that of n-butane		P 712.1	59	Mar.
Fugacity/pressure ratio		P 721.010.09	55	Apr.
Specific gravity of sulphuric acid solutions	(sheet 2)	P 725.113.2	119	Sept.
Equilibrium constants (K-values) of n-butane		P 771.214.740	81	Feb.
Equilibrium constants (K-values) of iso-butane		P 771.214.745	73	Jan.
Equilibrium constants (K-values of n-pentane		P 771.214.750	247	Oct.
Equilibrium constants (K-values) of iso-pentane		P 771.214.755	75	Jan.

*This index of the second twelve installments is now complete. A complete index of all tables included in installments 1 to 12 was published in the May, 1938, issue. The initial index of the third twelve installments will appear in next month's issue.

INDEX TO ADVERTISERS IN TABLES

		Page	*Issue*	*Backing Table No.*
American Rolling Mill Company	(sheet 3)	120	Aug.	P 644.200.1
American Rolling Mill Company	(sheet 2)	124	Sept.	P 448.430
American Rolling Mill Company	(sheet B)	142	Nov.	P 621.100.1
American Steel & Wire Company		116	Aug.	P 425.240.787
Baker Oil Tools, Inc.	(sheet 3)	130	June, 1938	P 448.425
Baker Oil Tools, Inc.	(sheet 4)	80	July	P 448.425
Baker Oil Tools, Inc.	(sheet 3)	86	Feb.	P 448.456
Bethlehem Steel Corporation	(sheet 3)	138	Nov.	P 519.5
Bethlehem Steel Corporation	(sheet 1)	78	Jan.	P 448.456
Bethlehem Steel Corporation		60	June, 1939	P 421.4
Broderick & Bascom Rope Company		128	June, 1938	P 425.240.556
Broderick & Bascom Rope Company		58	May	P 422.143.152
Chapman Valve Manufacturing Company		60	Mar.	P 712.1
Chapman Valve Manufacturing Company	(sheet 1)	58	Apr.	P 094.111.2
Chapman Valve Manufacturing Company	(sheet 1)	64	June, 1939	P 681.3
Climax Molybdenum Company	(sheet 2)	122	Sept.	P 519.5
Climax Molybdenum Company		140	Nov.	P 425.294.252
Climax Molybdenum Company	(sheet 1)	62	May	P 425.218.21
C. Lee Cook Manufacturing Company	(sheet 1)	60	Apr.	P 094.805
Crane Company	(sheet 1)	58	June, 1939	P 213.1
Diamond Chain and Manufacturing Company		136	June, 1938	P 533.300.4
Diamond Chain and Manufacturing Company	(sheet 2)	56	May	P 094.805
Fluid Packed Pump Company	(sheet 1)	82	July	P 519.5
Gilmore Wire Rope Division of Jones & Laughlin Steel Corporation	(sheet 3)	144	Nov.	P 448.430
Gilmore Wire Rope Division of Jones & Laughlin Steel Corporation		62	Mar.	P 425.215
Hanlon-Buchanan, Inc.		248	Oct.	P 771.214.750
Hanlon-Buchanan, Inc.		82	Feb.	P 771.214.740
Harrisburg Steel Company		56	Apr.	P 721.010.09
Harrisburg Steel Company	(sheet 1)	66	June, 1939	P 094.818.111
Hyatt Bearings Division, General Motors Corporation		126	Sept.	P 553.300.125
Hyatt Bearings Division, General Motors Corporation		58	Mar.	P 444.1
Hyatt Bearings Division, General Motors Corporation		60	May	P 094.710
Hyatt Bearings Division, General Motors Corporation	(sheet 2)	62	June, 1939	P 094.818.111
International Harvester Company	(sheet 2)	114	Aug.	P 644.200.1
Larkin Packer Company	(sheet 2)	62	Apr.	P 538.066
Larkin Packer Company		56	June, 1939	P 535.131
Layne & Bowler Company		118	Aug.	P 553.300.15
Linde Air Products Company		110	Aug.	P 615.110.30
Linde Air Products Company	(sheet A)	246	Oct.	P 621.100.1
Lunkenheimer Company	(sheet 2)	120	Sept.	P 725.113.2
Lunkenheimer Company		74	Jan.	P 771.214.745
Lunkenheimer Company		64	Mar.	P 094.818.11
Lunkenheimer Company	(sheet 2)	64	Apr.	P 094.111.2
MacClatchie Manufacturing Co.	(sheet 4)	72	Jan.	P 448.430
Macwhyte Company		112	Aug.	P 425.240.662
Merla Tool Company	(sheet 2)	88	Feb.	P 515.5
Mission Manufacturing Company	(sheet 3)	84	July	P 094.865.1
Patterson-Ballagh Corporation	(sheet 2)	80	Jan.	P 448.456
Petroleum Rectifying Company	(sheet 1)	132	June, 1938	P 515.5
Petroleum Rectifying Company		76	Jan.	P 771.214.755
Reed Roller Bit Company		124	June, 1938	P 425.240.450
Reed Roller Bit Company	(sheet 4)	90	Feb.	P 448.456
South Chester Tube Company	(sheet 1)	132	Sept.	P 448.430
South Chester Tube Company	(sheet 2)	64	May	P 425.218.21
Spang & Company		108	Aug.	P 424.22
Staynew Filter Corporation		126	June, 1938	P 615.108.30
Staynew Filter Corporation		250	Oct.	P 066.000
Thermoid Company		128	Sept.	P 425.240.237
Westinghouse Electric & Mfg. Company		134	June, 1938	P 094.14
Westinghouse Electric & Mfg. Company		130	Sept.	P 094.839
Westinghouse Electric & Mfg. Company	(sheet 2)	146	Nov.	P 094.603.1

A Decimal System for Classifying Data Pertaining to the Petroleum Industry

Part 6

By LESTER C. UREN

Professor of Petroleum Engineering, University of California, Berkeley, California

964. Marketing customs and practices.
.1 Price determination.
.11 Influence of crude production and storage on market price.
.2 Competitive conditions.
.3 Marketing combines.
965. Sales districts: regional markets. (Subdivide as under 100.)
966. Industrial markets: consuming industries and their marketing customs.
.1 The automotive industries.
.2 The transportation industries.
.21 Railroads.
.22 Shipping industry.
.3 Public utilities.
.4 Mines and quarries.
.5 Manufacturing industries.
.6 Building and structural industries.
.7 Domestic consumption of petroleum products.
.8 Influence of general industrial activity and development ment on the oil industry.
.9 Other data on the industrial markets for petroleum products.
967. Influence of competition with substitute products on petroleum markets.
.1 Coal.
.2 Benzol.
.3 Alcohol.
.4 Shale oil products.
.5 Vegetable oil products.
.6 Synthetic hydrocarbon products.
.7 Hydro-electric power.
969. Other data on marketing of petroleum products.
970. Conservation of petroleum resources.
971. Our dwindling reserves and necessity for conservation.
972. International aspects of the petroleum industry: competition for future reserves.
.1 War-time needs and uses for petroleum and petroleum products.
973. Government withdrawal legislation and petroleum land reserves.
974. Conservation in petroleum and natural gas production.
.1 Through exclusion of water from oil-producing formations.
.2 Through conservation of gas pressure in oil-producing formations.
.3 Voluntary unit operation of oil fields as a conservation measure.
.4 Voluntary proration and other forms of production control as a conservation measure. (See also under 986.)
.5 Conservation through avoidance of underground losses and by improvement in production methods.
975. Conservation in petroleum and natural gas storage and transportation
976. Conservation in petroleum refining.
977. Conservation in petroleum and natural gas utilization.
978. Petroleum and natural gas fire losses and methods of conservation through fire prevention.
.1 Municipal and underwriters' regulations on use of explosive and inflammable petroleum products.
979. Other data on consumption and conservation of petroleum resources.
980. Legislation and government regulation of the petroleum and related industries.
981. Laws of various countries and civil jurisdiction pertaining to the petroleum and related industries. (Subdivide as under 100.)
.111 Laws of the United States.
.112 Laws of Mexico.
.113 Laws of Canada, etc.
982. Taxation of the petroleum and related industries.
.1 Income taxes.
.2 Corporation taxes.
.3 Property taxes.
.4 Sales taxes.
.5 Import and export taxes.
.6 Social security taxes.
983. Corporation laws.
.1 Laws governing incorporation and activities of oil and gas companies.
.2 Laws governing sale of oil company securities.
.21 Rulings of Security Exchange Commission.
984. Laws governing land ownership and titles.
.1 The U. S. Placer Land Law.
.11 Mineral land locations under the Placer Law.
.12 Mineral land patents under the Placer Law.
.2 The U. S. Mineral Land Leasing Law.
.21 Prospecting permits under the Leasing Law.
.22 Leasing provisions of the Mineral Land Leasing Law.
.23 Government royalties and bonuses under the Leasing Law.
.24 Government inspection and regulation under the Leasing Law.
.3 Laws governing acquisition of land from private owners.
.31 Laws governing transfer of title in fee.
.32 Laws governing leasing practices.
.4 Laws governing reparation for damage to other owners.
.5 Laws governing right of entry and eminent domain.
.6 Riparian rights.
985. Labor legislation.
.1 Employers' liability laws.
.2 Industrial welfare legislation.
.21 Laws governing working time.
.22 Child labor laws.
.23 Laws governing working conditions.
.24 Minimum wage laws.
.25 Compulsory collective bargaining laws.
.3 Anti-strike legislation.
.31 Compulsory arbitration of industrial disputes.
.4 Immigration laws and their effect on the petroleum and related industries.
.5 Social security legislation.
986. Conservation laws.
.1 Water exclusion laws.
.2 Gas wastage prohibition laws.
.3 Government inspection laws and regulations.
.4 Laws governing protection of overlying noncommercial oil sands.
.5 Laws governing production control in the oil and gas industries.
.51 Proration laws and regulations.
987. Transportation and storage laws and regulations.
.1 Pipe line common-carrier laws.
.2 Laws governing shipment and storage of inflammable and explosive substances.
.3 Interstate commerce laws and regulations.
.4 State commission laws and regulations. (Subdivide as under 111.)
.5 Laws governing illegal transport of oil: Connally "hot oil" law, etc.
988. Laws governing marketing practices.
.1 Anti-trust laws.
.2 Public utility regulation. (In the natural gas industry.)
.3 Laws governing sales contracts.
.4 Laws governing responsibility of agents.
989. Other laws pertaining to the petroleum and related industries.
.1 War time regulation of the petroleum industry by Government.
990. Other data on economic phases of the petroleum and related industries.
991. History, progress, and development of the petroleum and related industries.
.1 Early historical references.
.3 Future of the petroleum and related industries.
992. Transportation as an economic element in the petroleum and related industries.

Attention!... USERS OF TABLES

THIS issue of THE PETROLEUM ENGINEER completes the second year of the Continuous Tables. The overwhelming reception accorded this feature by thousands of our readers has more than justified our belief that there was and is a need for this type of data among workers in the industry—practical and technical men alike.

The guiding purpose throughout has been to design tables to save time and effort for the technician and to assist the practical field or plant worker to solve problems commonly encountered in routine work. Necessarily, the tables have had to cover a variety of subjects in order to meet the needs of those engaged in the various branches of the industry served by THE PETROLEUM ENGINEER. How the scope of the tables has been varied is indicated by the following summary of tables thus far published:

Classification No.	*Subject*	*No. of Tables*
000. to 099.	General	23
200. to 299.	Physical and Chemical Properties	6
400. to 499.	Development of Deposits	
410.	Well spacing	1
420.	Drilling methods	27
430.	Casing wells	8
440.	Exclusion of water and gas	14
500. to 599.	Production of oil	
510.	Extraction of oil from wells	8
530.	Methods of stimulating production	18
540.	Gathering and treating	2
600. to 699.	Transportation, storage	
610.	Transportation of oil	10
620.	Natural gas transmission	2
640.	Oil storage	5
680.	Gauging and metering natural gas	1
700. to 799.	Oil refineries and refinery practice	
706.	Corrosion of refinery equipment	1
710.	Types of refineries	1
720.	Refinery processes	6
750.	Specific products	5
770.	Condensation of vapors	9
	Total	147

This issue marks also the concluding installment of the Dewey Decimal System as modified and extended for the petroleum industry by L. C. Uren, professor of petroleum engineering at the University of California. It has been gratifying to learn of the hundreds of individuals and oil companies who are rearranging their files in accordance with this system as presented in these pages and to know that THE PETROLEUM ENGINEER has been instrumental in making this valuable reference tool available to its readers.

As an indication of the manner in which THE PETROLEUM ENGINEER will continue to serve the industry as "A Magazine of Methods for Operating Men" A COMPREHENSIVE SUBJECT INDEX ARRANGED ALPHABETICALLY WILL BE PUBLISHED TO SUPPLEMENT AND INCREASE THE VALUE OF THE DECIMAL SYSTEM. This index will enable the man in the field or others not familiar with all the subdivisions of the system to find readily the particular subject desired. The index is being compiled by Professor Uren and will be published in convenient form in an early installment of The Continuous Tables.

Finally, it is planned to continue publication of the tables indefinitely, so long as there exists a demand among readers sufficient to justify such publication. The timeliness and usefulness of the tables is gauged by our knowledge of what the man in the field wants. You, as a reader, can aid materially in making the tables even more valuable by indicating to the Editors your ideas and needs concerning The Continuous Tables. Your suggestions are invited.

VOLUME OF LIQUID CONTAINED IN TUBING STRINGS, GAL. AND BBL.

Nominal diam. → / I.D. inches →	1¼-in. 1.380		1½-in. 1.610		2-in. 1.995		2½-in. 2.441		3-in. 2.922		3-in. 2.992		3½-in. 3.476		3½-in. 3.548		4-in. 3.958	
Length of tubing, ft.	gal.	bbl.	gal.	bbl.	gal.	bbl.	gal.	bbl.	gal.	bbl.	gal.	bbl.	gal.	bbl.	gal.	bbl.	gal.	bbl.
1	.1	.....	.1	.....	.2	.....	.2	0.01	0.3	0.01	0.4	0.01	0.5	0.01	0.5	0.01	.6	.02
2	.2	.....	.2	0.01	.3	0.01	.5	.01	.7	.02	.7	.02	1.0	.02	1.0	.02	1.3	.04
3	.2	0.01	.3	.01	.5	.01	.7	.02	1.0	.02	1.1	.03	1.5	.04	1.5	.04	1.9	.06
4	.3	.01	.4	.01	.7	.02	1.0	.03	1.4	.03	1.5	.03	2.0	.05	2.1	.05	2.6	.07
5	.4	.01	.5	.01	.8	.02	1.2	.04	1.7	.04	1.8	.04	2.5	.06	2.6	.06	3.2	.09
6	.5	.01	.6	.02	1.0	.03	1.5	.04	2.1	.05	2.2	.05	3.0	.07	3.1	.07	3.8	.11
7	.5	.01	.7	.02	1.1	.03	1.7	.05	2.4	.06	2.6	.06	3.5	.08	3.6	.09	4.5	.13
8	.6	.02	.8	.02	1.3	.04	1.9	.06	2.8	.07	2.9	.07	3.9	.09	4.1	.10	5.1	.15
9	.7	.02	1.0	.02	1.5	.04	2.2	.06	3.1	.07	3.3	.08	4.4	.11	4.6	.11	5.8	.17
10	.8	.02	1.1	.03	1.6	.05	2.4	.07	3.5	.08	3.7	.09	4.9	.12	5.1	.12	6.4	.19
20	1.6	.04	2.1	.05	3.2	.09	4.9	.14	7.0	.17	7.3	.17	9.9	.23	10.3	.24	12.8	.37
30	2.3	.06	3.2	.08	4.9	.14	7.3	.21	10.5	.25	11.0	.26	14.8	.35	15.4	.37	19.2	.56
40	3.1	.07	4.2	.10	6.5	.19	9.7	.28	13.9	.33	14.6	.35	19.7	.47	20.5	.49	25.6	.75
50	3.9	.09	5.3	.13	8.1	.24	12.2	.36	17.4	.41	18.3	.43	24.6	.59	25.7	.61	32.0	.93
60	4.7	.11	6.3	.15	9.7	.28	14.6	.43	20.9	.50	21.9	.52	29.6	.70	30.8	.73	38.4	1.12
70	5.4	.13	7.4	.18	11.4	.33	17.02	.50	24.4	.58	25.6	.61	34.5	.82	36.0	.86	44.7	1.31
80	6.2	.15	8.5	.20	13.0	.38	19.4	.57	27.9	.66	29.2	.70	39.4	.94	41.1	.98	51.1	1.49
90	7.0	.17	9.5	.23	14.6	.43	21.9	.64	31.4	.75	32.9	.78	44.4	1.06	46.2	1.10	57.5	1.68
100	7.8	.19	10.6	.25	16.2	.47	24.3	.71	34.8	.83	36.5	.87	49.3	1.17	51.4	1.22	63.9	1.87
200	15.5	.37	21.2	.50	32.5	.95	48.6	1.42	69.7	1.66	73.0	1.74	98.6	2.35	102.7	2.45	127.8	3.74
300	23.3	.56	31.7	.76	48.7	1.42	72.9	2.13	104.5	2.49	109.6	2.61	147.9	3.52	154.1	3.67	191.8	5.61
400	31.1	.74	42.3	1.01	65.0	1.90	97.2	2.84	139.3	3.32	146.1	3.48	197.2	4.69	205.4	4.89	255.7	7.47
500	38.9	.93	52.9	1.26	81.2	2.37	121.6	3.55	174.2	4.15	182.6	4.35	246.5	5.87	256.8	6.11	319.6	9.34
600	46.6	1.11	63.5	1.51	97.4	2.85	145.9	4.26	209.0	4.98	219.1	5.22	295.8	7.04	308.2	7.33	383.5	11.21
700	54.4	1.30	74.0	1.76	113.7	3.32	170.2	4.97	243.8	5.81	255.7	6.09	345.1	8.22	359.5	8.56	447.4	13.08
800	62.2	1.48	84.6	2.01	129.9	3.80	194.5	5.69	278.7	6.64	292.2	6.96	394.4	9.39	410.9	9.78	511.3	14.95
900	69.9	1.67	95.2	2.27	146.1	4.27	218.8	6.40	313.5	7.46	328.7	7.83	443.7	10.56	462.2	11.01	575.3	16.82
1,000	77.7	1.85	105.8	2.52	162.4	4.75	243.1	7.11	348.4	8.29	365.2	8.70	493.0	11.74	513.6	12.23	639.2	18.68
2,000	155.4	3.70	211.5	5.04	324.8	9.49	486.2	14.21	696.7	16.59	730.5	17.39	985.9	23.47	1027.	24.46	1278.	37.37
3,000	233.1	5.55	317.3	7.55	487.2	14.24	729.3	21.32	1045.	24.88	1096.	26.09	1479.	35.21	1541.	36.69	1918.	56.05
4,000	310.8	7.40	423.0	10.1	649.5	18.99	972.4	28.43	1393.	33.18	1461.	34.79	1972.	46.95	2054.	48.91	2557.	74.74
5,000	388.5	9.25	528.8	12.6	811.9	23.73	1216.	35.53	1742.	41.47	1826.	43.48	2465.	58.69	2568.	61.14	3196.	93.42
6,000	466.2	11.1	634.6	15.1	974.3	28.48	1459.	42.64	2090.	49.76	2191.	52.18	2958.	70.42	3082.	73.37	3835.	112.11
7,000	543.9	13.0	740.3	17.6	1137.	33.23	1702.	49.75	2438.	58.06	2557.	60.87	3451.	82.16	3595.	85.60	4474.	130.79
8,000	621.6	14.8	846.1	20.1	1299.	37.98	1945.	56.85	2787.	66.35	2922.	69.57	3944.	93.90	4109.	97.83	5113.	149.48
9,000	699.3	16.7	951.8	22.7	1461.	42.72	2188.	63.96	3135.	74.65	3287.	78.27	4437.	105.6	4622.	110.1	5753.	168.16
10,000	770.0	18.5	1058.0	25.2	1624.	47.50	2431.	71.07	3484.	82.94	3652.	86.96	4930.	117.4	5136.	122.3	6392.	186.85

Example: After swabbing-down a well to 9754 ft., the 2" tubing-string fills with oil up to 5433 ft. in 2 hr. What is the rate of fill-up in bbl. per hr.?

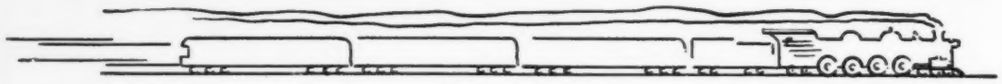
Solution: 9754 — 5485 = 4319

From table:

4000 ft. of 2" tubing contains	18.99 bbl.
300 ft. of 2" tubing contains	1.42 bbl.
10 ft. of 2" tubing contains	.05 bbl.
9 ft. of 2" tubing contains	.04 bbl.
4319 ft. of 2" tubing contains	20.50 bbl.

Therefore, the rate of fill-up is 10.25 bbl. per hr.

P 535.131



Give her the throttle-

CLEAR TRACK AHEAD!

With this LARKIN GUIDE SHOE there's always a clear track ahead, for no obstruction in the well can fracture it!

Larkin Genuine Bakelite Guide Shoes — scientifically engineered — will be there to the bottom, whole and undamaged. Their Guides of Fabric Base Bakelite (obtainable only in Larkin Equipment), are so tough and strong that they positively cannot be fractured or broken by collision or contact with any obstruction in the hole... Fabric Bakelite has a tensile strength of 7200 lbs., compared with 500 lbs. for concrete; and a compressive strength of 36,000 lbs., as against 3000 lbs. for concrete. Yet Bakelite is very light—only half the weight of concrete—hence is much more easily circulated out of the hole after being pulverized by the drill.

Fig. 411

The Steel part of Larkin Bakelite Guide Shoes is made from .60 carbon steel billets, having 77,000 lbs. tensile strength. Hob cut threads guarantee perfection as to pitch and taper. Each shoe is beveled for welding. Shoes can be threaded with any casing thread, including Hydril, Spang Extreme Line, or the new Round (Drill Pipe Form) Thread.

For an ideal cementing combination, use Larkin Bakelite Guide Shoes in conjunction with one or two Larkin Bakelite Float Collars. You'll like it!

At All Supply Stores

LARKIN PACKER COMPANY, INC. **ST. LOUIS, U. S. A.**

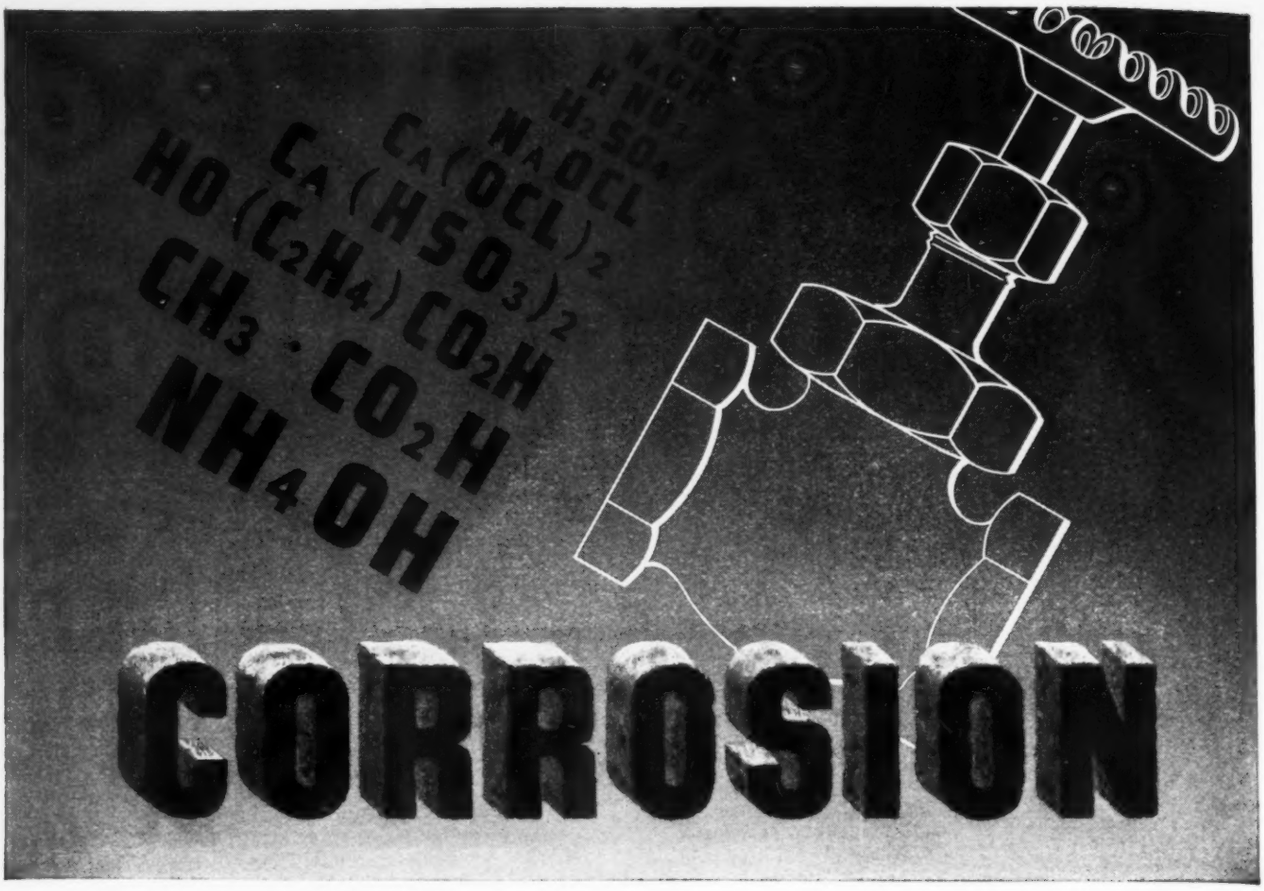
Export Office: 30 Rockefeller Plaza, New York

LARKIN PACKER CO.

SPECIFIC GRAVITY[1] CORRESPONDING TO A.P.I. GRAVITY

Whole degrees, A.P.I.	plus decimal parts of a degree									
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
10	1.0000	.9993	.9986	.9979	.9972	.9965	.9958	.9951	.9944	.9937
11	.9930	.9923	.9916	.9909	.9902	.9895	.9888	.9881	.9874	.9868
12	.9861	.9854	.9847	.9840	.9833	.9826	.9820	.9813	.9806	.9799
13	.9792	.9786	.9779	.9772	.9765	.9759	.9752	.9745	.9738	.9732
14	.9725	.9718	.9712	.9705	.9698	.9692	.9685	.9679	.9672	.9665
15	.9659	.9652	.9646	.9639	.9632	.9626	.9619	.9613	.9606	.9600
16	.9593	.9587	.9580	.9574	.9567	.9561	.9554	.9548	.9541	.9535
17	.9529	.9522	.9516	.9509	.9503	.9497	.9490	.9484	.9478	.9471
18	.9465	.9459	.9452	.9446	.9440	.9433	.9427	.9421	.9415	.9408
19	.9402	.9396	.9390	.9383	.9377	.9371	.9365	.9358	.9352	.9346
20	.9340	.9334	.9328	.9321	.9315	.9309	.9303	.9297	.9291	.9285
21	.9279	.9273	.9267	.9260	.9254	.9248	.9242	.9236	.9230	.9224
22	.9218	.9212	.9206	.9200	.9194	.9188	.9182	.9176	.9170	.9165
23	.9159	.9153	.9147	.9141	.9135	.9129	.9123	.9117	.9111	.9106
24	.9100	.9094	.9088	.9082	.9076	.9071	.9065	.9059	.9053	.9047
25	.9042	.9036	.9030	.9024	.9018	.9013	.9007	.9001	.8996	.8990
26	.8984	.8978	.8973	.8967	.8961	.8956	.8950	.8944	.8939	.8933
27	.8927	.8922	.8916	.8911	.8905	.8899	.8894	.8888	.8883	.8877
28	.8871	.8866	.8860	.8855	.8849	.8844	.8838	.8833	.8827	.8822
29	.8816	.8811	.8805	.8800	.8794	.8789	.8783	.8778	.8772	.8767
30	.8762	.8756	.8751	.8745	.8740	.8735	.8729	.8724	.8718	.8713
31	.8708	.8702	.8697	.8692	.8686	.8681	.8676	.8670	.8665	.8660
32	.8654	.8649	.8644	.8639	.8633	.8628	.8623	.8618	.8612	.8607
33	.8602	.8597	.8591	.8586	.8581	.8576	.8571	.8565	.8560	.8555
34	.8550	.8545	.8540	.8534	.8529	.8524	.8519	.8514	.8509	.8504
35	.8498	.8493	.8488	.8483	.8478	.8473	.8468	.8463	.8458	.8453
36	.8448	.8443	.8438	.8433	.8428	.8423	.8418	.8413	.8408	.8403
37	.8398	.8393	.8388	.8383	.8378	.8373	.8368	.8363	.8358	.8353
38	.8348	.8343	.8338	.8333	.8328	.8324	.8319	.8314	.8309	.8304
39	.8299	.8294	.8289	.8285	.8280	.8275	.8270	.8265	.8260	.8256
40	.8251	.8246	.8241	.8236	.8232	.8227	.8222	.8217	.8212	.8208
41	.8203	.8198	.8193	.8189	.8184	.8179	.8174	.8170	.8165	.8160
42	.8156	.8151	.8146	.8142	.8137	.8132	.8128	.8123	.8118	.8114
43	.8109	.8104	.8100	.8095	.8090	.8086	.8081	.8076	.8072	.8067
44	.8063	.8058	.8054	.8049	.8044	.8040	.8035	.8031	.8026	.8022
45	.8017	.8012	.8008	.8003	.7999	.7994	.7990	.7985	.7981	.7976
46	.7972	.7967	.7963	.7958	.7954	.7949	.7945	.7941	.7936	.7932
47	.7927	.7923	.7918	.7914	.7909	.7905	.7901	.7896	.7892	.7887
48	.7883	.7879	.7874	.7870	.7865	.7861	.7857	.7852	.7848	.7844
49	.7839	.7835	.7831	.7826	.7822	.7818	.7813	.7809	.7805	.7800
50	.7796	.7792	.7788	.7783	.7779	.7775	.7770	.7766	.7762	.7758
51	.7753	.7749	.7745	.7741	.7736	.7732	.7728	.7724	.7720	.7715
52	.7711	.7707	.7703	.7699	.7694	.7690	.7686	.7682	.7678	.7674
53	.7669	.7665	.7661	.7657	.7653	.7649	.7645	.7640	.7636	.7632
54	.7628	.7624	.7620	.7616	.7612	.7608	.7603	.7599	.7595	.7591
55	.7587	.7583	.7579	.7575	.7571	.7567	.7563	.7559	.7555	.7551
56	.7547	.7543	.7539	.7535	.7531	.7527	.7523	.7519	.7515	.7511
57	.7507	.7503	.7499	.7495	.7491	.7487	.7483	.7479	.7475	.7471
58	.7467	.7463	.7459	.7455	.7451	.7447	.7443	.7440	.7436	.7432
59	.7428	.7424	.7420	.7416	.7412	.7408	.7405	.7401	.7397	.7393
60	.7389	.7385	.7381	.7377	.7374	.7370	.7366	.7362	.7358	.7354
61	.7351	.7347	.7343	.7339	.7335	.7332	.7328	.7324	.7320	.7316
62	.7313	.7309	.7305	.7301	.7298	.7294	.7290	.7286	.7283	.7279
63	.7275	.7271	.7268	.7264	.7260	.7256	.7253	.7249	.7245	.7242
64	.7238	.7234	.7230	.7227	.7223	.7219	.7216	.7212	.7208	.7205
65	.7201	.7197	.7194	.7190	.7186	.7183	.7179	.7175	.7172	.7168
66	.7165	.7161	.7157	.7154	.7150	.7146	.7143	.7139	.7136	.7132
67	.7128	.7125	.7121	.7118	.7114	.7111	.7107	.7103	.7100	.7096
68	.7093	.7089	.7086	.7082	.7079	.7075	.7071	.7068	.7064	.7061
69	.7057	.7054	.7050	.7047	.7043	.7040	.7036	.7033	.7029	.7026
70	.7022	.7019	.7015	.7012	.7008	.7005	.7001	.6998	.6995	.6991

[1]The specific gravity corresponding to an A.P.I. gravity of 32.7 degrees, for example, will be found on line "32" in column ".7"



... How to combat it IN INDUSTRIAL PIPING

LET'S not kid ourselves about how easy it is to banish the costly nuisance of corrosion from process piping. It's a common menace—yet far from simple. The answers to corrosion problems are at no man's finger tips.

But Crane's new book—"Combating Corrosion in Industrial Process Piping"—is chock-full of the kind of information that's important to know in dealing with corrosive effects in piping. It's the most useful and dependable collection of facts on the subject ever assembled. Its pages reflect the scientific knowledge, the elaborate field and laboratory research, and the experience that are essential to practical solutions to corrosion problems.

To the valve user who digs deep for the facts about corrosion, this technical treatise brings valuable aid. Yet to every man concerned with piping —technician or not, it bears significant evidence of the thoroughness of Crane's efforts to help you in fighting corrosion.

And more than that! Because the same research and experience guide the manufacturing of Crane valves, here is assurance that they are designed with a knowledge of corrosion far beyond the simple relations of piping metals and corrosive fluids—that Crane-Quality in piping materials represents the finest developments of alloys for each specific application.

Let Crane help you combat corrosion successfully in your lines. In the facts of "Combating Corrosion in Industrial Process Piping," in Crane's 84-year experience, and in the broad Crane line of alloy valves and fittings, lies your best assurance of dependable flow control at reasonable cost. Consult your Crane Representative.

CRANE

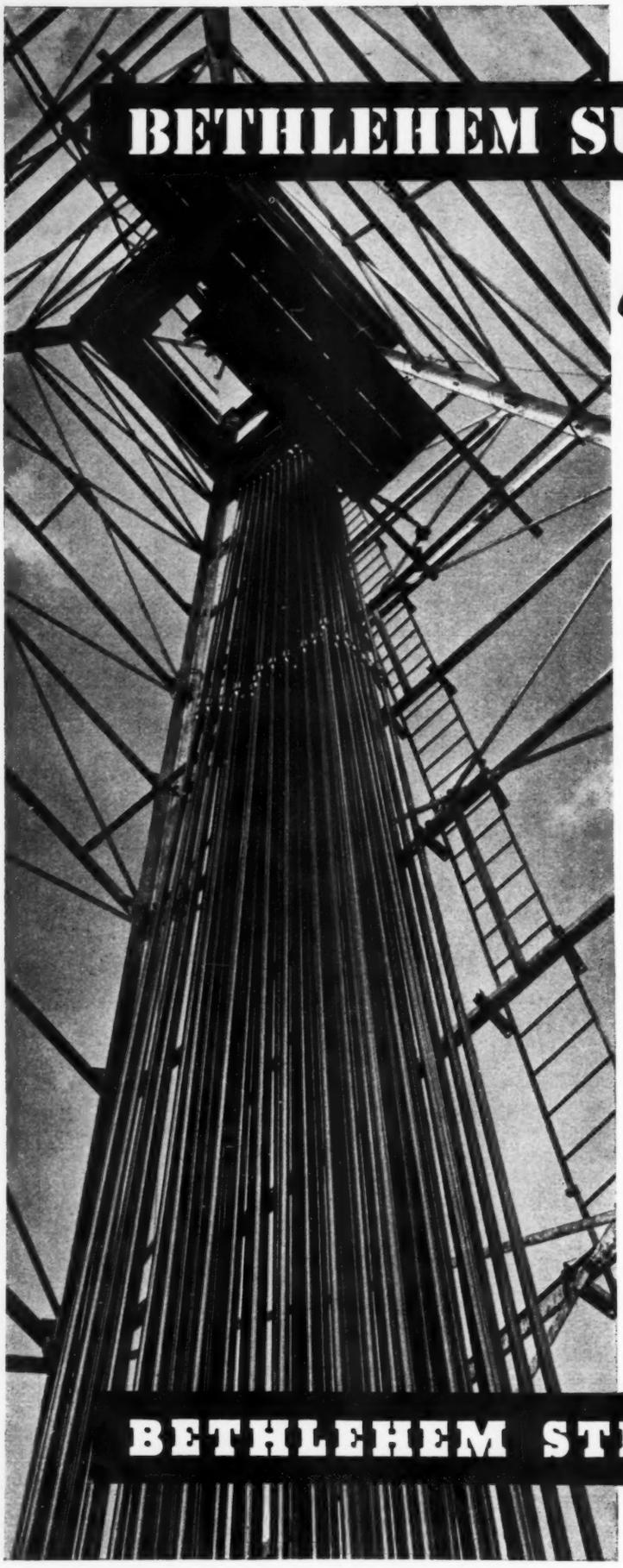
CRANE CO., GENERAL OFFICES
836 S. MICHIGAN AVE., CHICAGO
VALVES • FITTINGS • PIPE
PLUMBING • HEATING • PUMPS

NATION-WIDE SERVICE THROUGH BRANCHES AND WHOLESALERS IN ALL MARKETS

PRESSURE DROP[1] (LB. PER SQ. IN. PER 1000 FEET) IN WATER[2] LINES

Rate of flow, bbl. per hr.	Pipe diameter, in.								Rate of flow, gal. per min.
	1½	2	2½	3	3½	4	5	6	
5	.62	.19							3.5
10	2.00	.53	.27						7
15	4.17	1.28	.55	.20	.10				10.5
20	6.82	2.01	.91	.32	.16				14
25	10.1	3.08	1.33	.48	.24	.13			17.5
30	14.0	4.21	1.81	.64	.32	.18			21
35	18.2	5.55	2.38	.85	.43	.24			24.5
40	23.4	7.04	2.99	1.07	.53	.30	.10		28
45	27.9	8.61	3.70	1.32	.66	.36	.13		31.5
50	34.7	10.5	4.45	1.58	.80	.44	.15		35
55	41.2	12.3	5.31	1.88	.94	.51	.17		38.5
60	48.3	14.3	6.21	2.20	1.10	.60	.20		42
65	56.1	16.6	7.15	2.51	1.26	.69	.23		45.5
70	64.5	19.2	8.17	2.85	1.43	.79	.27	.11	49
75	73.3	21.9	9.30	3.23	1.62	.89	.30	.12	52.5
80	82.7	24.6	10.5	3.66	1.83	1.00	.34	.14	56
85	92.5	27.5	11.7	4.11	2.05	1.12	.38	.16	59.5
90	102.7	30.6	13.0	4.56	2.28	1.25	.42	.17	63
95	113.3	33.7	14.3	4.99	2.50	1.36	.46	.18	66.5
100	124.3	37.0	15.8	5.43	2.72	1.47	.50	.20	70
125		55.7	23.8	8.33	4.10	2.26	.74	.31	87.5
150		78.6	33.0	11.6	5.80	3.14	1.03	.43	105
175		107.0	44.0	15.4	7.75	4.20	1.38	.57	122.5
200			57.5	19.8	9.94	5.38	1.77	.72	140
225			71.3	24.6	12.1	6.56	2.20	.90	157.5
250			86.2	30.3	14.7	7.95	2.67	1.10	175
275				35.9	17.7	9.52	3.23	1.31	192.5
300				41.9	20.7	11.2	3.73	1.53	210
325				48.2	23.8	13.2	4.29	1.80	227.5
350				55.9	27.6	15.0	4.98	2.05	245
375				65.5	31.0	16.8	5.66	2.30	262.5
400					35.3	19.1	6.44	2.60	280
425					39.0	21.2	7.13	2.93	297.5
450					43.7	23.7	7.99	3.25	315
475					48.7	25.9	8.72	3.62	332.5
500					53.3	28.7	9.66	3.98	350
525					58.8	31.6	10.4	4.34	367.5
550						34.3	11.4	4.76	385
575						37.5	12.4	5.10	402.5
600						40.8	13.3	5.44	420

[1]For used pipe add 25%. Additional allowance must be made for ells, tees, and other fittings.
[2]For brine, multiply by the specific gravity for a close approximation.



BETHLEHEM SUCKER RODS

Reduce lifting costs

EVERY factor in the production of Bethlehem Sucker Rods is carefully calculated to make them stand up, to materially reduce down time and do a good job in cutting lifting costs.

It takes more than good steel to make a sucker rod. Quality in the steel, the right combination of properties, plus correct treatment and proper care in manufacture, are all part of the story in making Bethlehem Sucker Rods.

Metallurgists call the alloy content in Bethlehem Sucker Rods "balanced." It is so adjusted that the combination of physical properties responsible for their enviable service record is obtained without resorting to the more drastic forms of heat treatment.

Bethlehem's fifty years of experience in making fine steels and intimate knowledge of modern oil-field requirements are fully utilized in producing sucker rods of the highest quality. Bethlehem Sucker Rods are being used by large operators and independents alike in some of the country's toughest pumping jobs. They are reducing lifting costs in every major oil field.

BETHLEHEM STEEL

BETHLEHEM STEEL COMPANY

CAPACITY OF BURNER ORIFICES, CU. FT. PER HOUR, SP. GR. OF GAS .55

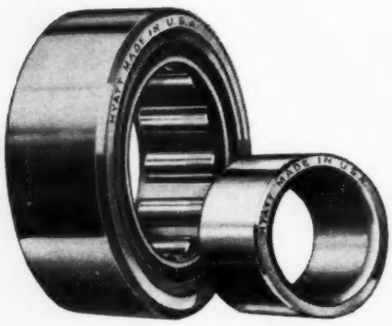
Size of orifice			Pressure, lb. per sq. in.								
In.	M.T. D.	Area sq. in.	50	40	30	25	20	18	16	14	12
1/16	....	.0031	190	170	147	134	120	114	107	100	93
	52	.0032	199	179	154	141	125	119	112	105	98
	51	.0035	226	202	175	159	142	135	127	119	110
	50	.0038	257	230	199	182	162	154	145	136	126
	49	.0042	286	256	222	202	180	171	161	151	140
	48	.0043	315	282	242	223	199	189	178	167	154
5/64	....	.0048	335	300	260	237	212	201	189	177	164
	47	.0049	342	306	265	242	216	205	193	181	167
	46	.0051	366	328	284	259	231	220	207	194	179
	45	.0053	382	342	296	270	241	229	216	202	187
	44	.0058	427	382	331	302	269	256	241	226	209
	43	.0062	471	422	365	333	298	283	266	249	231
	42	.0069	538	482	417	381	340	323	304	285	263
3/32	....	.0069	559	500	433	395	353	335	316	296	273
	41	.0072	590	527	457	417	372	353	332	312	288
	40	.0075	617	551	478	436	389	370	348	326	302
	39	.0078	634	567	492	449	400	380	358	336	310
	38	.0081	661	591	512	468	417	396	373	350	324
	37	.0085	692	619	537	490	437	415	391	366	339
	36	.0090	726	649	563	514	458	435	410	384	355
7/64	....	.0094	760	679	588	537	479	455	429	402	372
	35	.0095	764	683	592	540	482	458	432	404	374
	34	.0097	771	695	602	550	491	466	439	411	381
	33	.0100	804	719	623	569	508	482	454	426	393
	32	.0106	847	757	656	599	534	507	478	447	414
	31	.0113	871	779	675	616	550	522	492	460	426
1/8	....	.0123	902	807	699	638	570	541	510	477	442
	30	.0130	1052	941	815	744	664	631	594	556	515
	29	.0145	1175	1051	910	831	742	704	664	621	575
	28	.0155	1251	1119	969	885	790	750	707	661	612
9/64	....	.0156	1256	1123	973	888	792	752	709	664	614
	27	.0163	1293	1157	1002	915	816	775	731	684	633
	26	.0174	1347	1205	1044	953	850	807	761	712	659
	25	.0175	1394	1247	1080	986	880	836	787	737	682
	24	.0181	1430	1279	1108	1011	902	857	809	756	699
	23	.0186	1479	1323	1146	1046	933	886	835	782	724
5/32	....	.0192	1521	1361	1179	1076	960	912	859	804	744
	22	.0193	1524	1363	1181	1077	962	913	861	806	745
	21	.0198	1575	1409	1220	1114	994	944	890	833	771
	20	.0203	1611	1441	1248	1139	1017	965	910	852	788
	19	.0216	1698	1518	1316	1200	1072	1018	959	898	831
	18	.0226	1765	1579	1367	1248	1114	1058	997	934	863
11/64	....	.0232	1812	1620	1404	1281	1144	1086	1023	959	886
	17	.0235	1834	1640	1421	1297	1158	1099	1036	970	897
	16	.0246	1921	1718	1489	1359	1213	1152	1085	1016	940
	15	.0254	1964	1756	1522	1389	1239	1177	1109	1039	961
	14	.0260	2022	1808	1567	1430	1276	1212	1142	1070	989
	13	.0269	2095	1874	1624	1482	1322	1256	1184	1109	1025
3/16	....	.0276	2154	1926	1669	1523	1359	1291	1216	1139	1054
	12	.0280	2174	1944	1684	1537	1372	1303	1228	1150	1063
	11	.0286	2189	1958	1696	1548	1381	1312	1236	1158	1071
	10	.0294	2245	2007	1739	1587	1417	1345	1268	1187	1098
	9	.0302	2301	2057	1782	1627	1452	1379	1300	1217	1125
	8	.0311	2368	2117	1834	1674	1494	1419	1337	1253	1158
	7	.0317	2412	2157	1869	1706	1522	1446	1362	1276	1180
13/64	....	.0324	2473	2211	1916	1749	1560	1482	1397	1308	1210
	6	.0327	2495	2231	1933	1764	1574	1495	1409	1320	1220
	5	.0332	2546	2277	1973	1801	1607	1526	1438	1347	1246
	4	.0343	2624	2347	2033	1856	1656	1573	1482	1388	1284
	3	.0375	2703	2417	2094	1911	1706	1620	1527	1430	1322
7/32	....	.0384	2852	2551	2210	2017	1800	1709	1611	1509	1396
	2	.0408	2926	2617	2267	2062	1847	1754	1653	1548	1431
	1	.0430	3116	2787	2414	2204	1966	1867	1760	1648	1525
	A	.0431	3275	2929	2537	2316	2067	1962	1850	1732	1602
15/64	....	.0445	3281	2935	2542	2321	2071	1966	1853	1736	1605
	B	.0460	3380	3022	2619	2390	2133	2025	1909	1788	1653
	C	.0475	3552	3176	2752	2512	2241	2129	2006	1879	1737
	D	.0491	3665	3278	2840	2592	2313	2197	2070	1939	1793
1/4	E	.0519	3788	3388	2935	2679	2391	2270	2140	2004	1853
	F	.0535	4010	3586	3107	2836	2530	2403	2265	2121	1961
	G	.0554	4132	3696	3202	2923	2608	2477	2334	2186	2022
17/64	....	.0556	4280	3828	3316	3027	2701	2565	2417	2264	2094
	H	.0581	4300	3846	3322	3041	2714	2577	2429	2275	2104
	I	.0603	4485	4011	3475	3172	2831	2688	2534	2373	2194
	J	.0620	4648	4157	3602	3287	2934	2786	2626	2459	2274
	K	.0621	4794	4287	3714	3390	3025	2873	2708	2536	2345
9/32	....	.0660	4803	4295	3721	3397	3031	2878	2713	2541	2349
	L	.0683	5048	4515	3912	3570	3186	3026	2852	2671	2470
	M	.0692	5223	4671	4047	3694	3296	3130	2950	2763	2555
	N	.0716	5495	4915	4258	3886	3468	3293	3104	2907	2688
5/16	....	.0767	5969	5338	4625	4221	3773	3577	3372	3158	2920
	O	.0784	6101	5456	4727	4318	3850	3656	3446	3228	2984
	P	.0819	6445	5764	4993	4558	4067	3863	3640	3410	3153
21/64	....	.0845	6648	5946	5151	4702	4196	3984	3755	3517	3252
	Q	.0866	6804	6085	5272	4812	4294	4078	3844	3600	3329
	R	.0909	7061	6315	5471	4994	4457	4232	3989	3736	3454
11/32	....	.0928	7271	6503	5634	5142	4589	4358	4107	3847	3557
	S	.0951	7443	6657	5767	5264	4698	4461	4204	3938	3641
	T	.1007	7797	6973	6041	5514	4920	4673	4404	4125	3814
23/64	....	.1014	7865	7034	6094	5563	4964	4714	4443	4161	3848
	U	.1064	8245	7374	6389	5831	5204	4942	4658	4362	4034
3/8	....	.1104	8600	7692	6664	6083	5428	5155	4858	4550	4208
	V	.1116	8692	7774	6735	6147	5486	5210	4910	4599	4252
	W	.1170	9347	8359	7242	6610	5899	5602	5280	4945	4573
25/64	....	.1198	9570	8559	7415	6768	6040	5736	5406	5063	4682
	X	.1238	9872	8829	7649	6882	6230	5917	5576	5223	4829
	Y	.1282	10207	9128	7891	7219	6442	6117	5766	5400	4993
13/32	....	.1296	10350	9256	8019	7320	6532	6203	5846	5476	5063
	Z	.1340	10700	9570	8291	7568	6753	6413	6044	5661	5235
7/16	....	.1503	12000	10733	9298	8487	7574	7193	6779	6349	5871

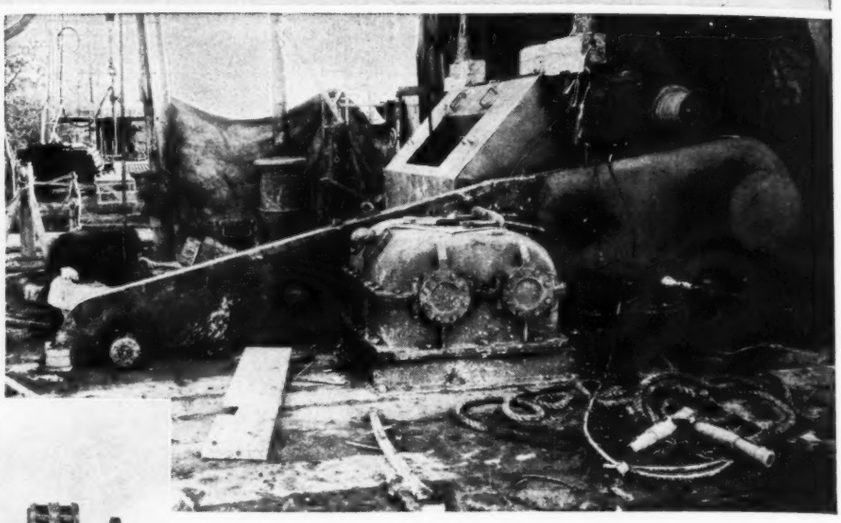
Correction factors

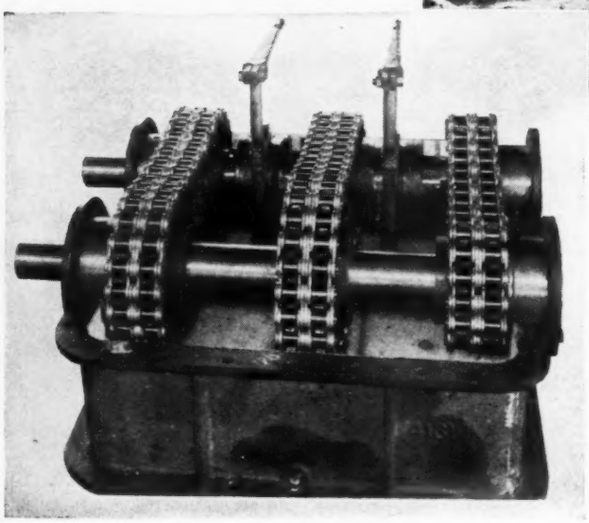
For gas of sp. gr. other than .55 multiply the values in the table by the following factors:

Sp. gr.	Factor
.34	1.27
.36	1.24
.38	1.20
.40	1.17
.42	1.14
.44	1.12
.46	1.09
.48	1.07
.50	1.05
.52	1.03
.54	1.01
.56	.988
.58	.973
.60	.956
.62	.942
.65	.920
.70	.887
.75	.857
.80	.829
.85	.805
.90	.783
.95	.762
1.00	.741
1.20	.678
1.40	.626
1.60	.587
1.80	.552
2.00	.524
2.20	.498
2.40	.479

NO MATTER WHERE_ _
YOU'LL FIND HYATTS THERE!







● **GUMBO BUSTER ROTARY DRIVE TRANSMISSION,** another American Well & Prospecting Company product made more dependable with Hyatt Roller Bearings. Above, transmission hooked up to drilling rig. Opposite, transmission with cover removed. The Bridgeport Machine Company is the distributor.

Thousands upon thousands of Hyatt Roller Bearings are in operation in all kinds of drilling machinery and many more are used in all other types of oil field equipment—engines, pumps, pumping units, etc.—Hyatts are everywhere! Designed and built to withstand the strains of punishing loads and speeds, to save on power and maintenance, Hyatts are the preferred bearings for this service. If you are contemplating new equipment, look for Hyatt Roller Bearings and their freedom from bearing wear and care. Hyatt Bearings Division, General Motors Sales Corporation, Harrison, New Jersey; Chicago, Pittsburgh, Detroit and San Francisco.

HYATT *Roller Bearings*

NATURAL GAS FLOW—CRITICAL VELOCITY, RATIO OF SPECIFIC HEATS, SPECIFIC VOLUME, ETC.

No.	Calculated gross heating value	Gas analysis: Methane CH_4	Gas analysis: Ethane C_2H_6	Gas analysis: Carbon dioxide CO_2	Gas analysis: Nitrogen N_2	Calculated specific gravity based on air = 1.0	Calculated ratio of specific heats, n	Calculated specific vol. at 60° F. & 1 atmos., cu. ft. per lb.	Critical Velocity Factor $\sqrt{gnV}$	Critical velocity, ft. per sec. at various pressures: Pressure, lb. per sq. in., absolute: 50	100	150	200	250	300	350	400	450	500
1	700	51.5	10.2	0.0	38.3	0.76	1.321	17.21	27.06	2295	3247	3978	4592	5133	5623	6075	6494	6889	7260
2	960	74.9	11.6	13.0	0.5	0.74	1.280	17.77	27.07	2297	3248	3979	4594	5135	5625	6077	6496	6892	7263
3	970	96.0	0.0	0.8	3.2	0.58	1.307	22.80	30.98	2629	3718	4554	5257	5877	6438	6955	7436	7888	8312
4	989	92.4	3.1	1.4	3.1	0.60	1.298	22.02	30.34	2574	3641	4460	5149	5755	6305	6811	7282	7725	8140
5	990	98.0	0.0	0.7	1.3	0.57	1.300	23.16	31.14	2642	3737	4578	6342	5907	6471	6991	7474	7928	8355
6	1002	91.3	4.5	0.8	3.4	0.60	1.309	21.94	30.41	2580	3649	4470	5161	5769	6319	6827	7298	7742	8159
7	1003	99.2	0.0	0.2	0.6	0.56	1.293	23.48	31.27	2653	3752	4597	5307	5932	6498	7020	7504	7961	8390
8	1012	97.3	0.0	0.4	2.3	0.59	1.300	23.11	31.10	2639	3732	4572	5278	5900	6463	6982	7464	7918	8344
9	1012	92.6	4.3	0.6	2.5	0.59	1.295	22.19	30.42	2581	3650	4472	5162	5771	6321	6829	7300	7745	8162
10	1013	78.3	12.6	0.2	8.9	0.66	1.299	20.05	28.94	2456	3473	4254	4911	5490	6014	6497	6946	7368	7765
11	1016	88.8	6.7	0.8	3.7	0.61	1.293	21.51	29.93	2540	3592	4400	5079	5678	6219	6719	7184	7620	8030
12	1037	66.5	20.7	0.3	12.5	0.71	1.286	18.49	27.67	2348	3320	4067	4696	5249	5750	6212	6640	7045	7424
13	1042	93.1	5.7	0.4	0.8	0.59	1.286	22.27	30.37	2577	3644	4464	5154	5761	6311	6818	7288	7732	8148
14	1048	91.9	6.8	0.0	1.3	0.59	1.292	22.14	30.35	2575	3642	4461	5150	5757	6307	6814	7284	7727	8143
15	1064	83.5	12.5	0.2	3.8	0.63	1.289	20.74	29.34	2489	3521	4313	4979	5566	6097	6587	7042	7470	7872
16	1065	69.4	20.6	0.1	9.9	0.70	1.277	18.84	27.83	2361	3340	4091	4723	5279	5783	6248	6680	7086	7467
17	1068	90.0	9.0	0.2	0.8	0.60	1.362	21.75	30.89	2621	3707	4541	5242	5860	6419	6935	7414	7865	8288
18	1074	75.4	17.7	0.3	6.6	0.67	1.291	19.57	28.52	2420	3422	4192	4840	5410	5926	6403	6844	7261	7652
19	1087	88.0	11.2	0.0	0.8	0.61	1.287	21.44	29.81	2529	3577	4382	5059	5655	6195	6692	7154	7590	7998
20	1093	74.8	19.1	0.3	5.8	0.68	1.288	20.41	29.09	2468	3491	4276	4937	5518	6045	6531	6982	7406	7805
21	1100	82.7	15.1	0.0	2.2	0.63	1.277	20.61	29.11	2470	3493	4279	4940	5522	6049	6535	6986	7409	7810
22	1150	79.8	19.5	0.0	0.7	0.65	1.284	20.13	28.85	2448	3462	4241	4896	5473	5995	6477	6924	7345	7740
23	1175	75.4	23.4	0.0	1.2	0.68	1.274	19.50	28.28	2400	3394	4157	4799	5365	5877	6349	6788	7200	7588
24	1192	73.2	25.6	0.0	1.2	0.69	1.273	19.20	28.06	2381	3367	4125	4762	5323	5831	6299	6734	7144	7528
25	1203	70.0	28.0	1.1	0.9	0.71	1.275	18.62	27.65	2346	3318	4065	4692	5245	5746	6207	6636	7040	7418
26	1251	66.6	32.7	0.0	0.7	0.72	1.265	18.33	27.32	2318	3278	4016	4636	5183	5677	6133	6556	6956	7330
27	1268	59.8	37.6	0.4	2.2	0.75	1.267	17.50	26.72	2267	3206	3928	4534	5069	5552	5999	6412	6803	7169
28	1510	32.3	67.0	0.0	0.7	0.89	1.242	14.88	22.79	1934	2735	3350	3867	4323	4736	5116	5470	5802	6115
29	1510	37.5	59.6	0.0	1.7	0.86	1.241	15.55	24.93	2115	2992	3665	4231	4729	5180	5597	5984	6347	6689

Remarks: (1) Critical velocity in the vena contracta equals the velocity of sound in the gaseous medium considered. Velocity of sound in a gaseous medium may be expressed as follows:

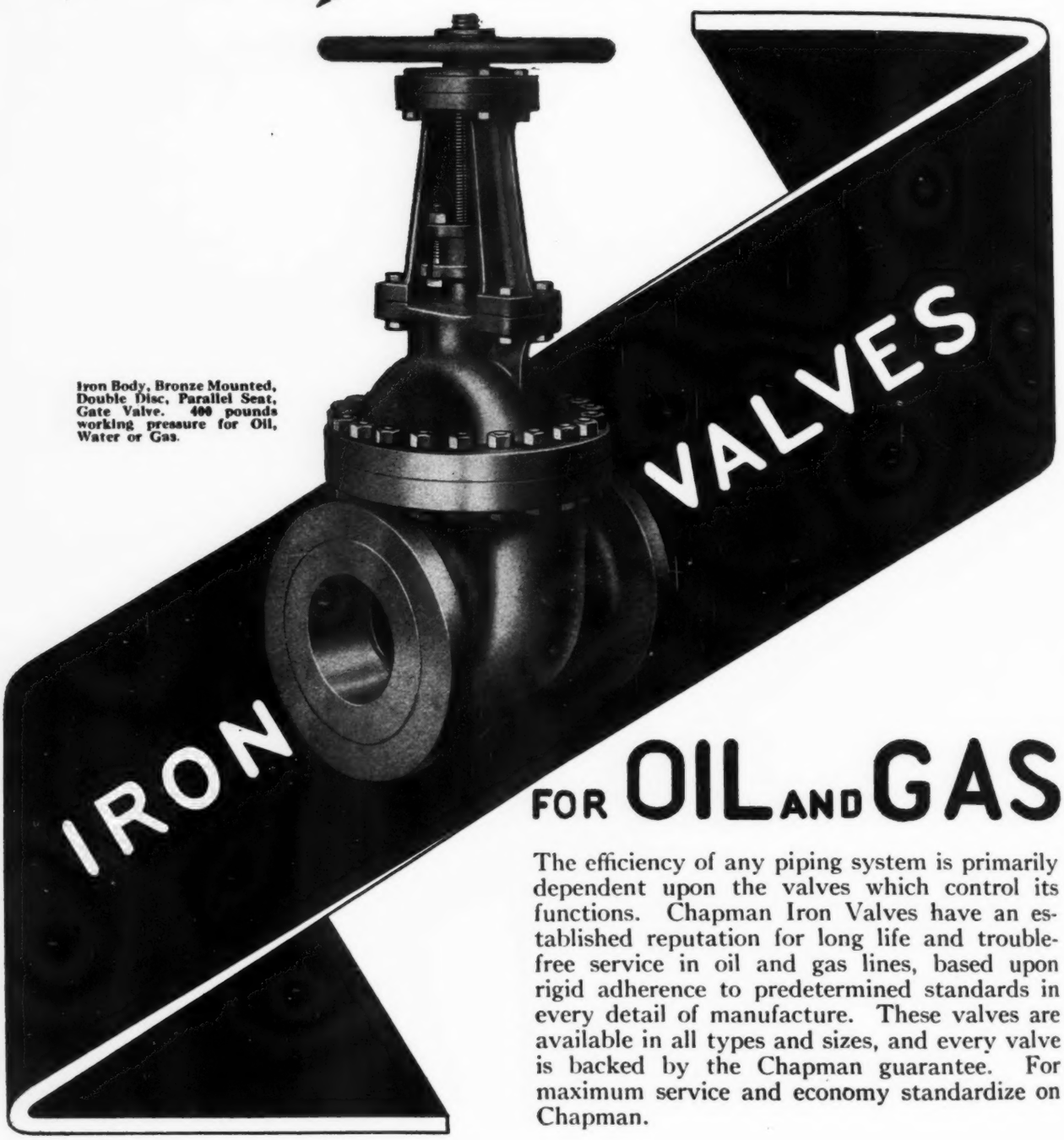
$$v = \sqrt{gnpV}$$

where
- v = velocity of sound, ft. per sec.
- g = acceleration of gravity, ft. per sec. per sec.
- n = ratio of specific heats
- p = absolute pressure, lb. per sq. ft.
- V = specific volume, cu. ft. per lb.

(2) Critical velocity at other pressures than shown may be calculated by multiplying the critical velocity factor (as shown above) by the square root of the pressure expressed in lb. per sq. ft. absolute.

(3) Deviation from Boyles' Law has been disregarded.

Chapman



Iron Body, Bronze Mounted, Double Disc, Parallel Seat, Gate Valve. 400 pounds working pressure for Oil, Water or Gas.

FOR OIL AND GAS

The efficiency of any piping system is primarily dependent upon the valves which control its functions. Chapman Iron Valves have an established reputation for long life and trouble-free service in oil and gas lines, based upon rigid adherence to predetermined standards in every detail of manufacture. These valves are available in all types and sizes, and every valve is backed by the Chapman guarantee. For maximum service and economy standardize on Chapman.

THE CHAPMAN VALVE
MANUFACTURING COMPANY
INDIAN ORCHARD, MASS.

CAPACITY OF BURNER ORIFICES, CU. FT. PER HOUR, SP. GR. OF GAS .55

Size of orifice		Pressure, lb. per sq. in.									
In.	M.T. D.	10	9	8	7	6	5	4	3	2	1
1/16	....	85	81	76	71	66	60	54	47	38	27
	52	89	84	80	74	69	63	56	49	40	28
	51	101	96	90	85	78	71	64	55	45	32
	50	115	109	103	96	89	81	72	63	51	36
	49	128	121	114	107	99	91	80	70	57	40
	48	141	134	126	118	109	100	90	77	63	45
5/64	....	150	142	134	125	113	106	94	82	67	47
	47	153	145	137	128	118	108	96	84	68	48
	46	164	156	147	137	127	116	104	90	73	52
	45	171	162	153	143	132	121	108	94	76	54
	44	191	181	171	160	148	135	120	105	85	60
	43	211	200	189	177	163	149	134	116	94	67
	42	241	229	216	202	187	170	152	132	108	76
3/32	....	250	237	224	209	194	177	158	137	112	79
	41	264	250	236	221	204	187	166	145	118	83
	40	276	262	247	231	214	195	174	151	123	87
	39	284	269	254	238	220	201	180	156	127	90
	38	296	281	265	248	229	209	188	162	132	94
	37	310	294	277	259	240	219	196	170	139	98
	36	325	308	291	272	252	230	206	178	145	103
7/64	....	340	323	304	284	263	240	214	186	152	107
	35	342	324	306	286	265	242	216	187	153	108
	34	348	330	311	291	270	246	220	191	156	110
	33	360	342	322	301	279	255	228	197	161	114
	32	379	360	339	317	294	268	240	208	169	120
	31	390	370	349	326	302	276	246	214	174	123
1/8	....	404	383	361	338	313	286	256	221	181	128
	30	471	447	421	394	365	333	298	258	211	149
	29	526	499	470	440	407	372	332	286	235	166
	28	560	531	501	469	434	396	354	307	250	177
9/64	....	562	533	503	470	435	397	356	308	251	178
	27	579	549	518	484	448	409	366	317	259	183
	26	603	572	539	504	467	426	382	330	270	191
	25	624	592	558	522	483	441	394	342	279	197
	24	640	607	572	535	496	453	404	351	286	202
	23	662	628	592	554	513	468	418	353	296	209
5/32	....	681	646	609	570	528	482	430	373	305	215
	22	682	647	610	571	528	482	432	374	305	216
	21	705	669	631	590	546	499	446	386	315	223
	20	721	684	645	603	558	510	456	395	322	228
	19	760	721	680	636	589	537	480	416	340	240
	18	790	749	707	661	612	559	500	433	353	250
11/64	....	811	769	725	679	628	573	512	444	363	256
	17	821	779	734	687	636	581	520	450	367	260
	16	860	816	769	720	666	608	544	471	385	272
	15	879	834	786	735	681	622	558	481	393	279
	14	905	859	809	757	701	640	572	496	405	286
	13	938	890	839	785	727	663	594	514	419	297
3/16	....	964	915	862	807	747	682	610	528	431	305
	12	973	923	870	814	754	688	616	533	435	308

Size of orifice		Pressure, lb. per sq. in.									
In.	M.T. D.	10	9	8	7	6	5	4	3	2	1
	11	980	930	877	820	759	693	620	537	438	310
	10	1005	953	899	841	778	711	636	550	449	315
	9	1030	977	921	862	798	728	652	564	461	326
	8	1060	1006	948	887	821	750	670	581	474	335
	7	1080	1025	966	904	837	764	684	592	483	342
13/64	....	1107	1050	990	926	857	783	700	606	495	350
	6	1117	1060	999	935	865	790	706	612	500	353
	5	1140	1081	1020	954	883	806	720	624	510	360
	4	1175	1115	1051	983	910	831	744	644	525	372
	3	1210	1148	1082	1012	937	856	766	663	541	383
7/32	....	1277	1211	1142	1068	989	903	808	699	571	404
	2	1310	1243	1172	1096	1015	926	828	717	586	414
	1	1395	1323	1248	1167	1081	986	882	764	624	441
	A	1466	1391	1311	1227	1136	1037	928	803	656	464
15/64	....	1469	1394	1314	1229	1138	1039	930	805	657	465
	B	1513	1435	1353	1266	1172	1070	956	829	677	478
	C	1590	1508	1422	1330	1232	1124	1006	871	711	503
	D	1641	1557	1468	1373	1271	1160	1038	899	734	519
1/4	E	1696	1609	1517	1419	1314	1199	1072	929	758	536
	F	1795	1703	1605	1502	1390	1269	1136	983	803	568
	G	1850	1755	1655	1548	1433	1308	1170	1013	827	585
17/64	....	1916	1818	1714	1603	1484	1355	1212	1049	857	606
	H	1925	1826	1722	1611	1491	1361	1218	1054	861	609
	I	2008	1905	1796	1680	1555	1420	1270	1100	898	635
	J	2081	1974	1861	1741	1612	1471	1316	1140	931	658
	K	2146	2036	1919	1795	1662	1517	1358	1175	969	679
9/32	....	2150	2040	1923	1799	1665	1520	1360	1178	972	680
	L	2260	2144	2021	1891	1751	1598	1430	1238	1011	715
	M	2338	2218	2091	1956	1811	1653	1478	1281	1046	739
	N	2460	2334	2200	2058	1906	1739	1554	1347	1100	777
5/16	....	2672	2535	2390	2236	2070	1889	1690	1463	1195	845
	O	2731	2591	2443	2285	2115	1931	1728	1496	1221	864
	P	2885	2737	2580	2414	2235	2040	1824	1580	1290	912
21/64	....	2976	2823	2662	2490	2305	2104	1882	1630	1331	941
	Q	3046	2890	2724	2548	2359	2154	1926	1668	1362	963
	R	3161	2999	2827	2645	2449	2235	1992	1731	1414	996
11/32	....	3255	3088	2911	2723	2521	2302	2058	1783	1456	1029
	S	3332	3161	2980	2788	2581	2356	2108	1825	1490	1054
	T	3490	3311	3122	2920	2703	2468	2208	1911	1561	1104
23/64	....	3521	3340	3149	2946	2727	2490	2226	1928	1575	1113
	U	3691	3502	3301	3088	2859	2610	2334	2022	1651	1167
3/8	....	3850	3652	3444	3221	2982	2722	2434	2109	1722	1217
	V	3891	3691	3480	3255	3014	2751	2460	2131	1740	1230
	W	4184	3969	3742	3501	3241	2959	2646	2292	1871	1323
25/64	....	4284	4064	3832	3584	3318	3029	2710	2346	1916	1355
	X	4419	4192	3952	3697	3423	3125	2794	2420	1976	1397
	Y	4569	4335	4087	3823	3539	3231	2890	2502	2043	1445
13/32	....	4633	4395	4144	3876	3589	3376	2930	2537	2072	1465
	Z	4790	4544	4284	4008	3710	3387	3030	2623	2142	1515
7/16	....	5372	5096	4805	4494	4161	3799	3398	2942	2402	1699

Correction factors

For gas of sp. gr. other than .55 multiply the values in the table by the following factors:

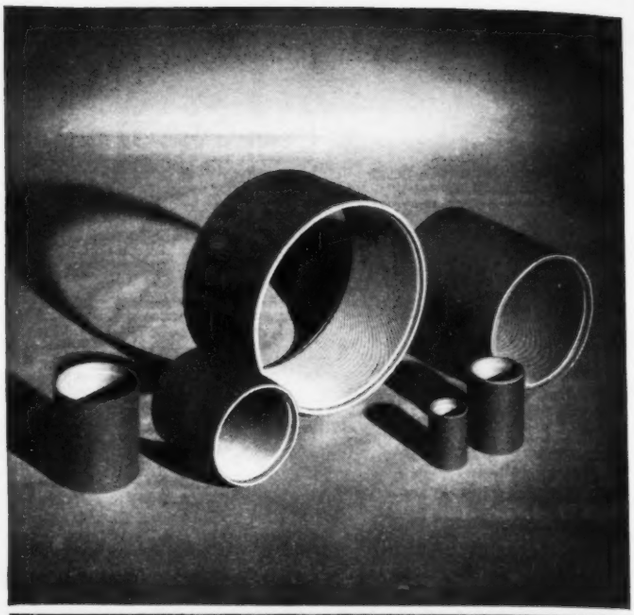
Sp. gr.	Factor
.34	1.27
.36	1.24
.38	1.20
.40	1.17
.42	1.14
.44	1.12
.46	1.09
.48	1.07
.50	1.05
.52	1.03
.54	1.01
.56	.988
.58	.973
.60	.956
.62	.942
.65	.920
.70	.887
.75	.857
.80	.829
.85	.805
.90	.783
.95	.762
1.00	.741
1.20	.678
1.40	.626
1.60	.587
1.80	.552
2.00	.524
2.20	.498
2.40	.479

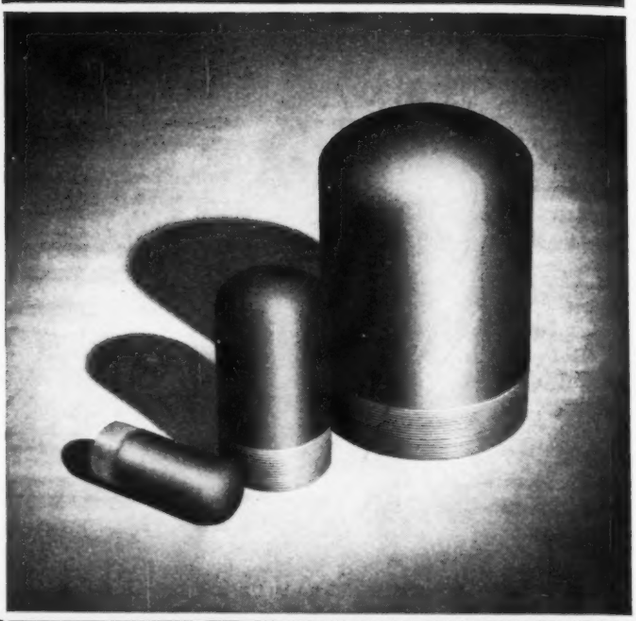
HARRISBURG COUPLINGS

...Precision Cut for Perfect Fit

When couplings fail, leakage, waste and costly interruption of service must result. But in precision-made Harrisburg Couplings, progressive petroleum engineers secure unusual protection. These sturdy seamless units are forged individually from solid billets of special steel ...machined by an exclusive process pioneered by Harrisburg. Their strip-proof threads are unsurpassed for uniform accuracy of form, height, angle and lead.

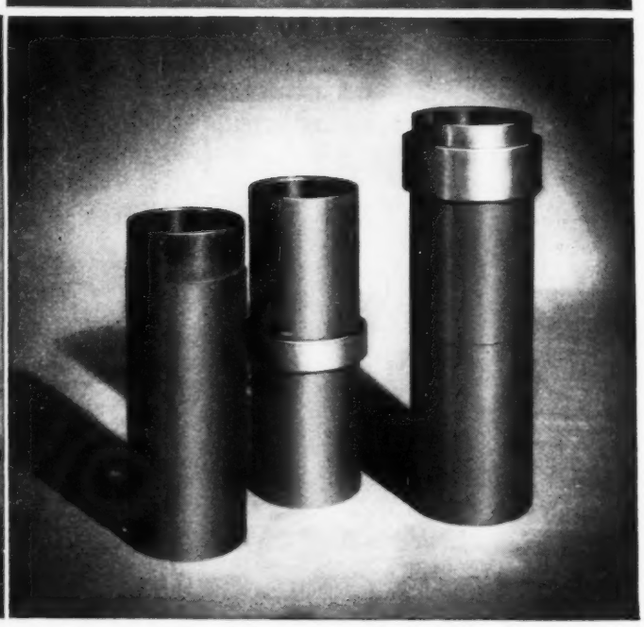
Equally durable and economical in service are Harrisburg's famous alloy and carbon steels, seamless steel cylinders, liquefiers and pump liners, hollow and drop forgings, pipe flanges, and pipe coils and bends.





HARRISBURG STEEL CORPORATION

HARRISBURG • PENNSYLVANIA



P 206.31
P 597.

A Field Balance for Weighing Pipe to Determine Rate of Corrosion[1]

A 10-ft. length of lead or flow line can be weighed in the field to a degree of accuracy comparable to that of the laboratory analytical balance

By T. H. MARSHALL, Acting Head,
Chemical Engineering Department
and
D. CHADS, Research Assistant,
Chemical Engineering Department, University of Kansas

THE Chemical Engineering Department of the University of Kansas, cooperating with the Kansas State Board of Health and the producers of crude petroleum in Kansas, is making a study of oil-field-brine corrosion. Boyce has recommended subsurface disposal, i.e., the return of oil-field brine to geological formations that normally contain mineralized water.[2] Brine-disposal wells in some localities have become plugged. Chemical analyses of samples from the plugged wells show products of supersaturation and products of reaction between the metal pipe and brine. Taylor, Wilhelm, and Holliman report the products of corrosion to be 75 percent of the solids found in plugged disposal wells.[3] Corrosion reduces metal thickness and shortens the life of disposal wells.

Corrosion has been a subject of research for many years. A review of the literature reveals the following characteristics common to this research: first, almost all investigations have been made in a laboratory; second, small specimens have been employed; third, field conditions have been simulated; fourth, the number of variables has been kept to a minimum; fifth, the laboratory balance has been the one scientific instrument common to all corrosion studies; sixth, laboratory results, although comparable, do not explain nor compare with field corrosion rates. Field conditions cannot be duplicated in a laboratory, and all variables will affect the rate of corrosion. Corrosion specimens have, as a general rule, been selected for convenience and their total mass has been limited by the accuracy of the analytical balance available; therefore the balance has been the limiting factor in most corrosion studies.

Realizing the advantages of conducting a corrosion experiment under actual field conditions and employing specimens assembled in lead and brine lines, the writers sought to determine the feasibility of designing and constructing a balance to weigh accurately large test sections of pipe. The features deemed desirable for such an instrument were: accuracy comparable to that of an analytical balance; ruggedness, or sufficient strength to support

[1]This report represents work of the Chemical Engineering Department, Engineering Experiment Station, of the University of Kansas, in cooperation with the Kansas State Board of Health.

D. CHADS

was born at Lakefield, Ontario, Canada, 24 years ago—Attended High School in Lakefield and Medicine Lodge, Kansas—Received his bachelor's degree in chemical engineering from University of Kansas, June, 1938—From September, 1938, to present has been research assistant, Chemical Engineering Department, University of Kansas.

[2]Boyce, Earnest, The Disposal of Brine from Oil Drilling and Petroleum Operations, *Journal of the American Water Works Association*, Vol. 29, No. 3, March, 1937.

[3]Taylor, S. S., Wilhelm, C. V., and Holliman, W. C., Typical Oil-Field Brine-Conditioning Systems: Preparing Brine for Sub-Surface Injection. A cooperative report between the Bureau of Mines and the Kansas State Board of Health. (To be published in 1939.)

T. H. MARSHALL

received a bachelor's degree in chemical engineering from Iowa State College in 1927, a master's degree from Lehigh University in 1930, and the degree of chemical engineer from Iowa State College in 1936. He was assistant chemist of the Iowa State Highway Commission for a year—Laros Silk Company Research Fellow at Lehigh University for almost two years—Five years an instructor in chemical engineering, Case School of Applied Science—From September, 1935, to present at University of Kansas, until February, 1938, as assistant professor of chemical engineering, now acting head of the Chemical Engineering Department. Is a member of Lambda Chi Alpha, Alpha Chi Sigma, Sigma Xi, and the American Institute of Chemical Engineers.

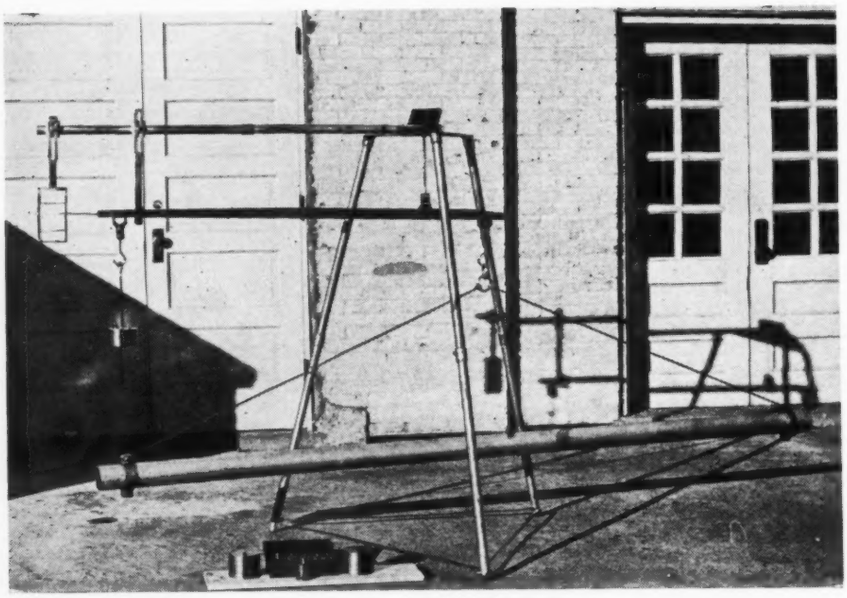


Fig. 1. The balance assembled

entire sections of 2-in. or 3-in. standard pipe, and portability, or ease of separation into parts convenient for transporting in a motor car. An instrument to meet these specification has been designed, constructed, and tested for accuracy. It has been used for the last three months to study the rates of corrosion of 10-ft. test sections installed in lead and brine lines. At present five test sections provided with suitable bypasses have been installed by interested producers.

The assembled view of this balance is shown in Fig. 1. There are four essential parts, namely, a supporting tripod, beam assembly, sample suspension sling, and suspension device for the weights. The ratio of the balance beam is five to one, i.e., the measured distance from the fulcrum knife edge to the specimen knife edge is one-fifth the measured distance from the fulcrum knife edge to the weight knife edge. The beam when balanced perfectly will come to rest or a measured equidistance swing of the pointer may be read in a manner similar to the technique employed for weighing by analytical balance.

The supporting tripod, Fig. 2, consits of a head plate, three legs, three tie rods, and a horizontal arm. A 17-in. head plate in the form of an equilateral triangle, Fig. 3, was cut from $\frac{3}{16}$-in. mild steel. A 1-in. standard coupling was welded to each corner at an angle of 15 deg. Three legs made from 1-in. standard pipe threaded into the head plate couplings support the balance. Each leg is made of two short sections threaded into a coupling. The head plate of the tripod is 5 ft. above the base elevation when assembled. Tie rods supported by hooks 1 in. above the base of each leg insure rigidity of the tripod. The horizontal tripod arm was constructed of two short sections of 1-in. pipe coupled together and supported by a coupling welded to the horizontal head plate. This arm supports the beam-arresting device and pointer scale.

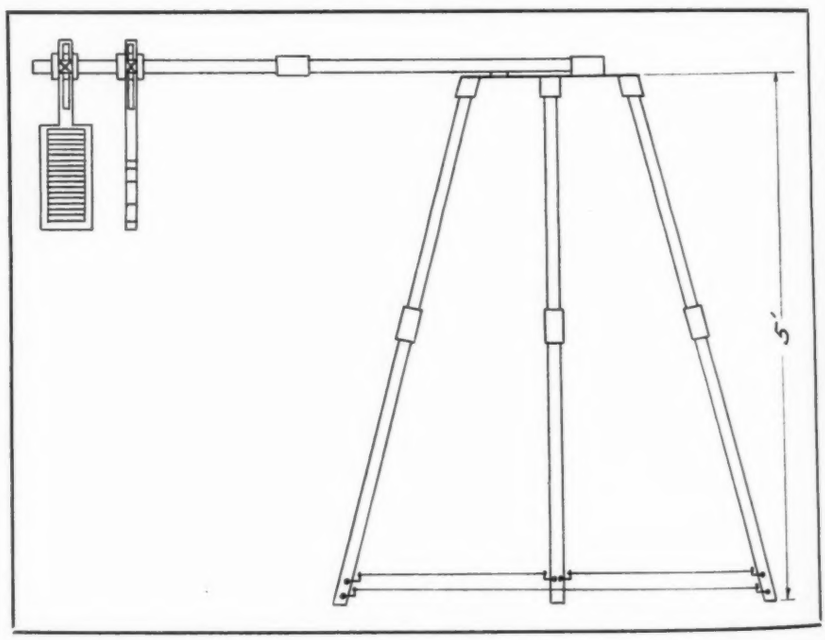
The assembled beam is shown in Fig. 4. This assembly includes the beam, knife edges, toggle-type hangers, pointer scale, and beam-arresting device. The beam, Fig. 5, 60 in. long

TABLE I
WEIGHING OF STANDARD SECTION

No.	Date		Time	Temp., °F.	Pressure, cm. Hg	Relative wt., grams	Corrected* relative wt., grams
	Month	Day					
1	Oct.	14	2:30 p. m.	88	73.68	C+70.7800	C+70.7832
2	Oct.	14	3:30 p. m.	87	73.68	C+70.7850	C+70.7857
3	Oct.	25	9:00 a. m.	86	73.76	C+70.8000	C+70.8007
4	Oct.	26	1:30 p. m.	83	73.83	C+70.8000	C+70.8007
5	Oct.	26	3:30 p. m.	85	73.81	C+70.7500	C+70.7507
6	Nov.	24	11:30 a. m.	72	.....	C+70.8000	C+70.8007
7	Nov.	24	12 noon	72	.....	C+70.7950	C+70.7957
8	Nov.	24	1:00 p. m.	79	.....	C+70.8000	C+70.8007
9	Jan.	12	2:30 p. m.	86	73.74	C+70.8200	C+70.8207
10	Jan.	16	4:00 p. m.	80	73.64	C+70.8300	C+70.8307

C=a constant weight factor common to each weighing.
*Fractional weight corrections applied.

Fig. 2. Tripod



LUNKENHEIMER SERVES THE OIL INDUSTRY

with a Complete Line for Steam, Water, Air, Gasoline and Oil Service

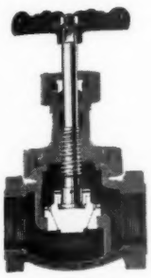


Fig. 1857-P
150 lb. S.P. Plug Type
All-Iron "Ferrenewo"

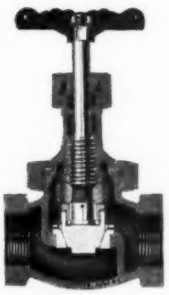


Fig. 16-P
300 lb. S.P. Plug Type
Bronze "Renewo"

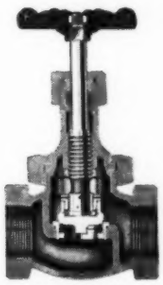


Fig. 1878
350 lb. S.P.
Bronze Globe

Fig. 1720
600 lb. S.P.
Steel Globe

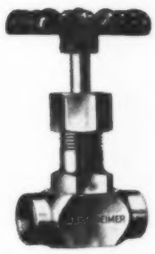


Fig. 1730
3000 lb. W.O.G.
Steel Needle Valve

Fig. 2125
125 lb. S.P.
Double Wedge Disc
Bronze Gate

Fig. 2129
125 lb. S.P.
Single Wedge Disc
Bronze Gate

Fig. 1640
150 lb. S.P.
Iron Body
"King-clip" Gate

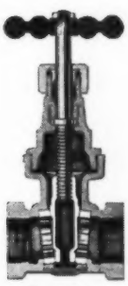


Fig. 768
200 lb. S.P.
Single Wedge Disc
Bronze Gate

Fig. 1881
350 lb. S.P.
Single Wedge Disc
Bronze Gate

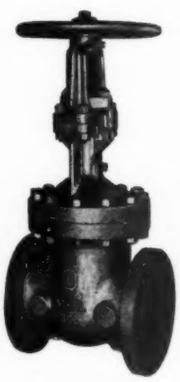


Fig. 1938-D2
300 lb. S.P.
Steel Gate

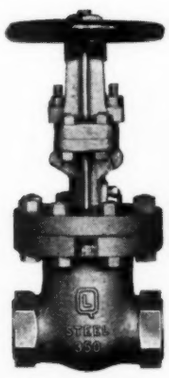


Fig. 1869-B6
350 lb. S.P.
Steel Gate

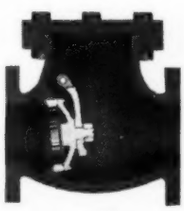


Fig. 1790
125 lb. S.P.
Iron Body Swing Check

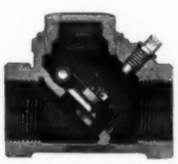


Fig. 1880
350 lb. S.P.
Bronze Regrinding
Swing Check

Fig. 1123
125 lb. S.P.
Iron Body Globe

Fig. 1430
125 lb. S.P.
Iron Body Gate

ESTABLISHED 1862

THE LUNKENHEIMER CO.

"QUALITY"

CINCINNATI, OHIO, U. S. A.

NEW YORK CHICAGO
BOSTON PHILADELPHIA

EXPORT DEPT. 318-322 HUDSON ST., NEW YORK

CARRIED IN STOCK BY LUNKENHEIMER DISTRIBUTORS

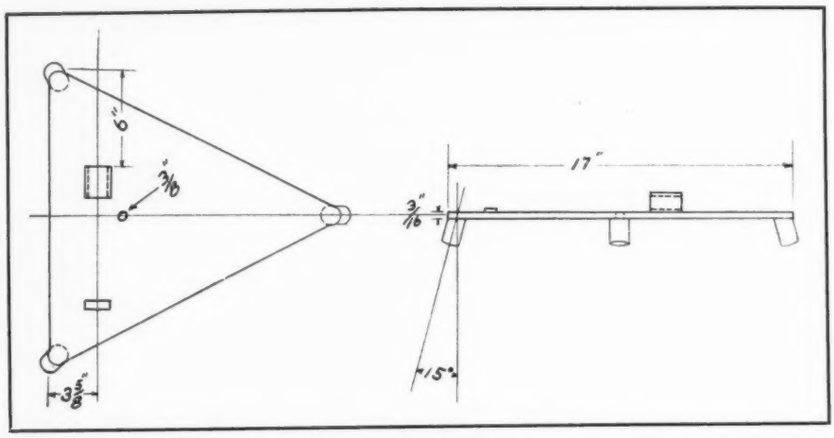


Fig. 3. Head plate

and ½ in. wide, was cut from an Alleghany metal bar and varies in height from 1 in. at each end to 2 in. in the fulcrum section. The knife edges, Fig. 6, were made from Swedish steel, and wedged, Fig. 7, into the Alleghany metal beam. All knife edges lie in the same horizontal plane, and have honed finishes. Toggle-type hangers, Fig. 8, serve as knife-edge rests at the three suspension points. The fulcrum toggle hanger has a rod welded to it so that it may be bolted to the head plate. Supporting hooks were welded to the other toggle hangers. The balance pointer, one end of which is threaded, fits into a drilled and tapped hole in the long end of the balance beam. The beam-arresting device limits the vertical angle through which the beam may swing. The pointer scale is suspended behind the pointer. The arresting device and pointer scale are adjustable and suspended from the tripod arm.

The sample pipe specimen is suspended from the front toggle-hanger hook by means of a sling constructed of two rings, four hook-and-eye rods, and two clamps. The clamps may be securely bolted around the circumference of the pipe. Rods attached to the clamp bolts lead to a common set of rings. The top ring is placed over the front balance hook. A sling of this type is not as convenient as a cable or chain sling but it can be cleaned readily and has proved to be very satisfactory. All Alleghany metal parts of the balance are heat-polished. The other metal parts with the exception of the tripod are nickel-plated.

Three sets of weights are necessary. The specimen is first roughly counterbalanced by large weights. These weights are made of brass, have smooth surfaces, and are slotted. The intermediate weights have a range of 100 to 1000 grams. The final balance is made by analytical weights. The tops of the large brass weights serve as excellent surfaces upon which to place the small weights. A suitable hanger constructed of a rod bent into a hook at the top and welded to a flat disk at the bottom serves as a support for the slotted weights. This weight hanger is hooked to the rear toggle-hanger hook.

The balance is readily assembled in the following manner. The tripod is set up and the head plate leveled. The balance rest and scale are then bolted to the horizontal tripod arm. The rear end of the assembled beam is placed through the balance-arresting device and the fulcrum hanger bolted to the head plate. The protecting corks are removed from the knife edges and the pointer set in place. The previously cleaned specimen, clamps and suspen-

Fig. 4. Assembled beam

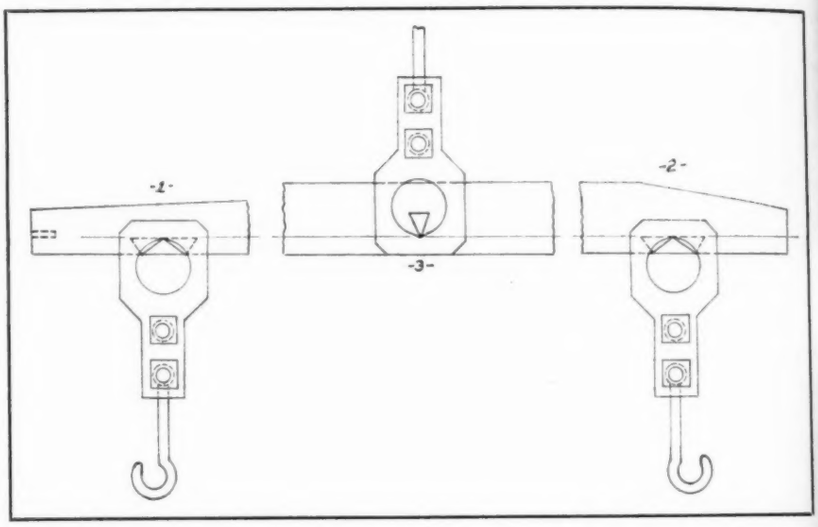
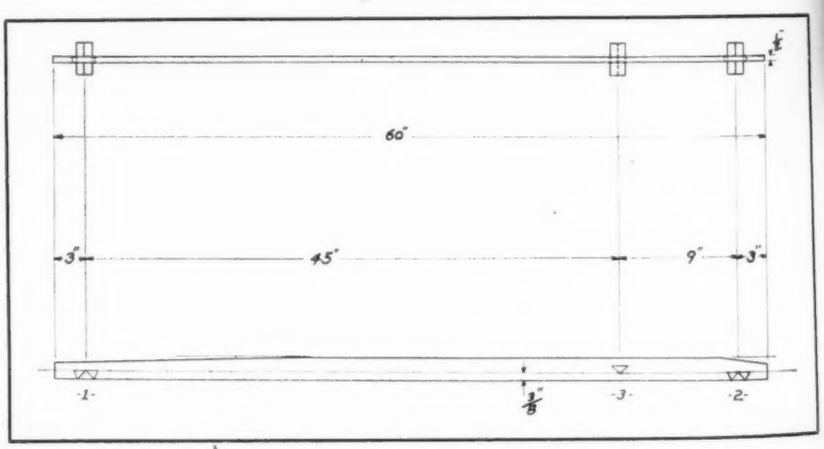


Fig. 5. Beam

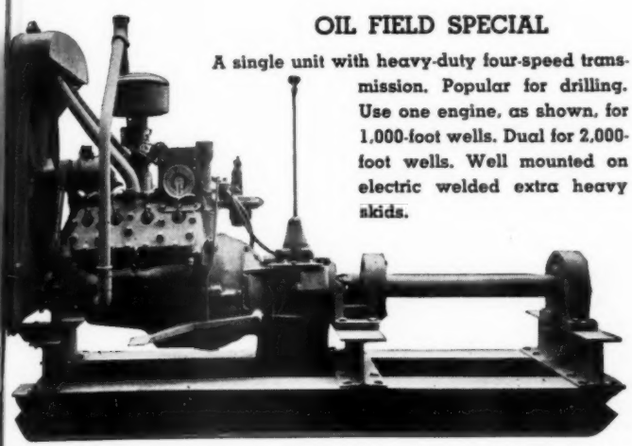


Hot Weather Proof!

•

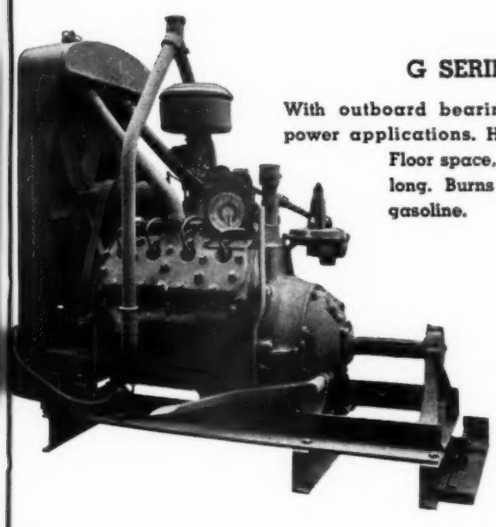
GENERAL POWER UNITS . . . . . for

DRILLING — PUMPING — GENERATING



OIL FIELD SPECIAL

A single unit with heavy-duty four-speed transmission. Popular for drilling. Use one engine, as shown, for 1,000-foot wells. Dual for 2,000-foot wells. Well mounted on electric welded extra heavy skids.



G SERIES

With outboard bearings for general power applications. Has large clutch. Floor space, 27" wide, 61½" long. Burns natural gas or gasoline.

Radiators especially designed for stationary work. Tanks are all brass, with copper core. Frontal cooling area has 684 sq. in. of exposed core. Cooling system has water capacity of ten gallons.

General Power units have been establishing outstanding records for economical operation on stationary power installations. Records show that with ordinary maintenance these units give 4,000 to 6,000 hours service before an overhaul is required. Then the regular Ford engine exchange plan puts a factory conditioned engine back in the unit.

Complete units include new truck type engine, double fan belts, 6-blade 20-inch aluminum fan, special designed heavy-duty radiator for industrial use. Oil bath air cleaner, starter, 17-plate battery. Gasoline carburetor, gasoline pump. Natural gas units include flyball governor, combination carburetor, valve box, gasometer type regulator.

There are seven units in the General line with one engine.

General Power Units using Ford 60, 85 and 95 h.p. and Lincoln-Zephyr engines are available in Single, Dual or Multiple belt driven units.

Write, Wire or Phone

GENERAL POWER, Inc.

QUAPAW, OKLAHOMA PHONE 64

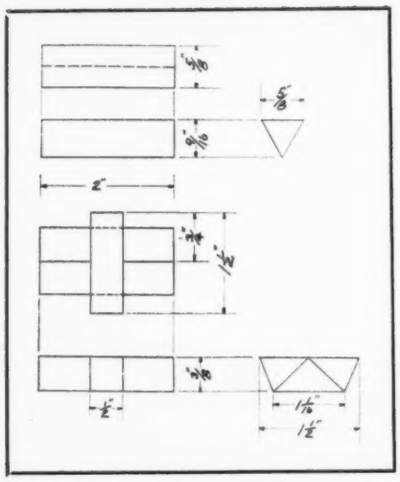


Fig. 6. Knife edges. Fulcrum No. 3 (top); Points Nos. 1 and 2 (below)

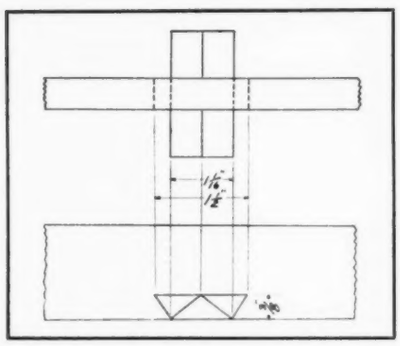


Fig. 7. Detail of wedging

sion rods attached, is hung on the front balance hook. The weight holder is hung on the rear hook and sufficient weights added to balance the beam roughly. The beam is then adjusted by placing a spirit level on the top surface of the beam near the fulcrum. This section of the top is parallel to the base of the beam and the plane of the knife edges and consequently is horizontal.

The beam rest is adjusted for an equidistant swing. While the beam is horizontal the pointer scale is adjusted to read zero. The balance adjustment is checked and routine weighing procedure then followed. In the field, weighings are made inside any available building, and every necessary precaution is taken to insure accuracy.

For testing the balance a standard section of 3-in. pipe was cleaned and a number of weighings made. No difficulty was encountered in balancing the beam on a quiet day in the open or at any time in the laboratory. Accurate

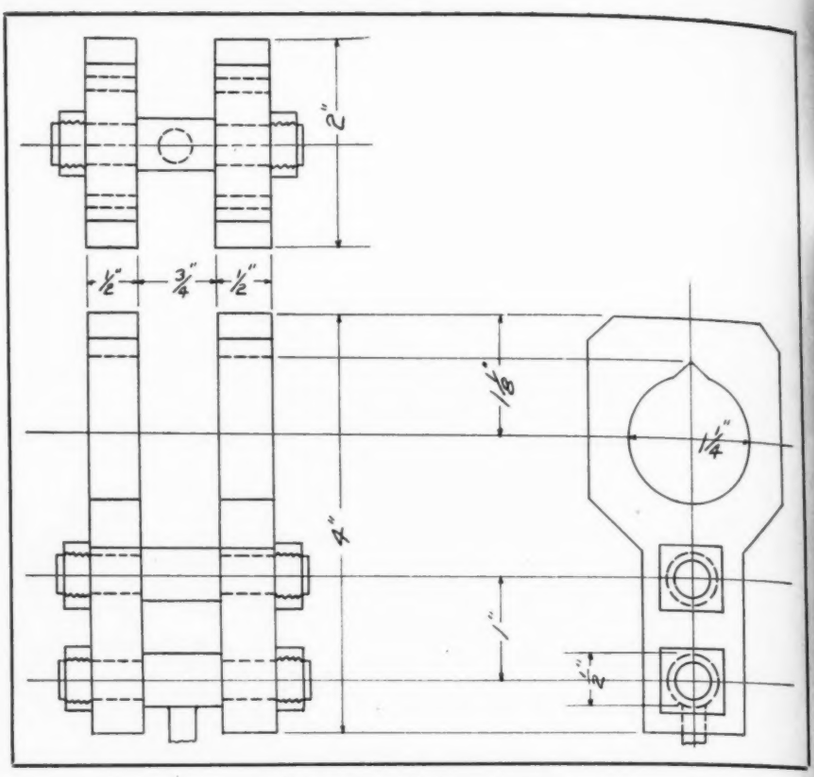


Fig. 8. Toggle-type hangers

weighings can be made only when the surrounding air is calm. Small particles of dust settling on the pipe, moisture in the air precipitating on the pipe, and the vibration of operating pumps have been found to affect weighings seriously. For convenience, and to minimize installation cost, 10-ft. test sections provided with suitable bypasses have been selected for field installations. To conform with field practice, a 10-ft. section was adopted for calibration work in the laboratory. This section of pipe was cleaned and the outside given a coat of aluminum paint. A special method has been developed for cleaning the inside and outside of all test sections, and is applied to this so-called standard section as well as all field test sections before weighings are made.

TABLE 2

EFFECT OF HUMIDITY ON WEIGHT OF STANDARD SECTION

No.	Date		Time	Temp., °F.	Pressure, cm. Hg	Relative wt., grams	Corrected* relative wt., grams
	Month	Day					
Normal humidity							
1	Oct.	14	2:30 p. m.	88	73.68	C+70.780	C+70.7832
2	Oct.	25	9:00 a. m.	86	73.76	C+70.800	C+70.8007
3	Oct.	26	1:30 p. m.	83	73.83	C+70.800	C+70.8007
4	Nov.	24	11:30 a. m.	72	.....	C+70.800	C+70.8007
Humidity above normal							
1	Dec.	1	10:30 a. m.	76	73.67	C+71.540	C+71.5459
2	Dec.	1	8:30 a. m.	78	73.69	C+71.750	C+71.7559
3	Dec.	2	11:30 a. m.	74	73.37	C+71.410	C+71.4109
4	Dec.	3	9:30 a. m.	83	73.20	C+72.270	C+72.2726
5	Dec.	3	10:30 a. m.	75	73.18	C+72.300	C+72.3026
6	Dec.	3	11:30 a. m.	76	73.17	C+72.290	C+72.2926
7	Dec.	7	9:30 a. m.	88	73.78	C+71.660	C+71.6609
8	Dec.	7	11:30 a. m.	85	73.79	C+71.635	C+71.6359

C = a constant weight factor common to each weighing.
*Fractional weight corrections applied.

NEW FEATURES for One of the Oil Country's Most Popular Pumping Units

"OILWELL" SC-10
PUMPING UNIT

"Oilwell" SC-10 Pumping Unit with short base. Universal slide rails at the samson post can be furnished for electric-motor drive. Straight and L-shaped extended-bases are also available, both with remote brake control and universal slide rails for a wide selection of prime movers.

Polished Rod Load Capacity (A.P.I.)	(pounds)	10,000
Peak Torque Capacity at 20 s.p.m. (A.P.I.)	(inch-pounds)	56,500
Over-all Gear Ratio		32 : 1
Stroke Lengths	(inches)	22½, 30, 37½

The widely used "Oilwell" No. 10 Pumping Unit now becomes the "Oilwell" SC-10, giving you these additional features:

1. Higher samson post.
2. Stronger walking beam.
3. Heavier sub-base.
4. New-type pitman with a roller bearing and a self-lubricated knuckle-joint at the top and a self-aligning spherical roller bearing at the bottom. The crank pin may be moved from one crank hole to another without disconnecting any part of the pitman assembly.
5. New-style crank with counterweight (optional) which clears the derrick floor.
6. Choice of arc-type, straight-lift hanger or a new, oilbath, rubber-cushioned, link hanger.
7. Optional "V" attachment with roller-bearing pull-rod strap for pumping a second well; also a special crank-pin bearing housing with roller-bearing clevis for pumping a third well.

Ask for complete specifications and prices.

OIL WELL SUPPLY COMPANY
Branch Stores in all Oil Fields
Subsidiary of United States Steel Corporation

"OILWELL"

To simplify the design of this balance no counterweight device was included to compensate for the beam ratio; therefore, the weight necessary to balance the beam and suspended sample accurately is a relative weight. The difference between any two relative weights over a definite interval of time multiplied by five is the actual weight difference. Data observed in a series of weighings of a standard 10-ft. section of pipe have been tabulated in Table 1. These data show that consistent weights may be determined. All measurements recorded in tabulated form were made in the chemical engineering department's unit operations laboratory. Conditions in such a laboratory are not consistently favorable, as often moisture from an open evaporator will cause a change in the humidity of the air. The effect of varying humidity is shown in Table 2, as open evaporators were operating continuously from December 1st to December 7th.

In the study of corrosion the balance is used to determine the difference in weight over a period of time. To prove the accuracy to which the field balance may determine small differences in weight, analytical weights were placed in the pipe and a series of experimental weighings made to determine the percentage accuracy of weight differences. This experiment was conducted by adding 20, 50, 100, and 200 grams to the pipe. The results of this experiment are tabulated in Table 3. The percentage error is small. Field results are showing losses ranging from 20 to 500 grams per month, which is comparable to the laboratory experimental range.

In comparing the accuracy of balances it is necessary to consider the number of significant figures observed in a weight determination. On the analytical balance most research workers read six significant figures. The results tabulated here were measured for a sample pipe, the mass of which exceeded 30,000 grams. All weighings were made to the nearest five milligrams; therefore, the total number of significant figures is eight. Granting that the five-milligram weight is an estimate, there remain seven significant figures for consideration.

This balance has been designed, constructed, and tested and is being used to study corrosion of lead and brine pipe lines. The project is being conducted as a field study so that it is not necessary to simulate conditions; actual specimens serve as samples; the results have been favorable, and when sufficient data have been collected, a report of the study will be made.

The writers wish to acknowledge the assistance of the Oil Field Waste Disposal Section of the Kansas State Board of Health, the producers of crude petroleum coöperating in the installation of test sections, and Fowler Shops of the University of Kansas.

TABLE 3a
PERCENTAGE ERROR

Orig. wt., grams	Final wt., grams	Difference, grams	Difference ×5	Percentage error
20 grams added				
70.5807	74.5463	3.9656	19.8280	.86
71.1759	75.1421	3.9662	19.8310	.85
71.1759	75.1447	3.9688	19.8440	.78
71.6359	75.6007	3.9648	19.8240	.88
70.8007	74.7651	3.9644	19.8220	.89
70.9257	74.8889	3.9632	19.8160	.92

TABLE 3b
PERCENTAGE ERROR

Orig. wt., grams	Final wt., grams	Difference, grams	Difference ×5	Percentage error
50 grams added				
71.1459	81.1059	10.0400	50.200	.42
70.8007	80.7833	9.9826	49.813	.40
70.8007	80.7831	9.9824	49.812	.38
70.9257	80.8847	9.9590	49.795	.41
71.1579	81.1457	9.9880	49.840	.36
70.5807	80.5391	9.9584	49.792	.42
72.2926	82.2532	9.9606	49.803	.40
71.3059	81.2659	9.9600	49.800	.38

TABLE 3c
PERCENTAGE ERROR

Orig. wt., grams	Final wt., grams	Difference, grams	Difference ×5	Percentage error
100 grams added				
70.7757	90.7085	19.9328	99.664	.44
70.6557	90.6095	19.9538	99.769	.33
70.9057	90.8263	19.9206	99.603	.40
70.7407	90.7705	19.9298	99.649	.35
70.6457	90.5657	19.9200	99.600	.40
70.7757	90.7385	19.9628	99.814	.19
70.8007	90.7515	19.9508	99.754	.25

TABLE 3d
PERCENTAGE ERROR

Orig. wt., grams	Final wt., grams	Difference, grams	Difference ×5	Percentage error
200 grams added				
70.7757	110.6763	39.9006	199.503	.25
70.8007	110.7049	39.9042	199.521	.24
70.6757	110.5841	39.9084	199.542	.23
70.7457	110.6743	39.9286	199.643	.18
70.8257	110.7337	39.9080	199.540	.23
70.8007	110.7229	39.9222	199.611	.19
70.6957	110.6037	39.9080	199.540	.23
70.8007	110.7285	39.9278	199.639	.18

Oil's first choice

FOR TOUGH JOBS!

OIL men in increasing numbers agree that NATIONAL Seamless is "tops" for tough jobs. And this means wherever holes are unusually deep, pressures abnormally high, and strata particularly hard to penetrate—NATIONAL Seamless Drill Pipe, Casing, and Tubing are first choice. This preference has been hard-earned.

Records on file tell how NATIONAL Seamless Drill Pipe produces thousands of feet of hole in the world's deepest wells with smooth, dependable performance . . . how NATIONAL Seamless Casing withstands terrific subterranean pressures . . . how NATIONAL Seamless Tubing's fatigue and wear-resisting characteristics protect profits when the well goes on the pump.

No wonder oil men breathe easier when their investments are guarded by NATIONAL Seamless. For NATIONAL Seamless means "Walls Without Welds"—pierced from a solid billet of highest-quality steel. In NATIONAL Seamless there is no line of potential weakness—each tube is a perfectly formed steel cylinder, with full wall strength at every point.

If you are not already using NATIONAL Seamless Drill Pipe, Casing, and Tubing, call in a representative of National Tube and get first-hand a full picture of the advantages of standardizing on NATIONAL Seamless for the complete well job. Send for Bulletin No. 15.

***NATIONAL SEAMLESS** means pierced from solid billets of the finest quality steel. Only sound and flawless steel can be used for piercing, since any existing defects cannot be covered up in this process. A thorough system of inspections and tests at every stage in production gives you double assurance that each length of* NATIONAL *Seamless will display the same uniform wall strength, dimensional accuracy, and uniformity in all physical properties.*

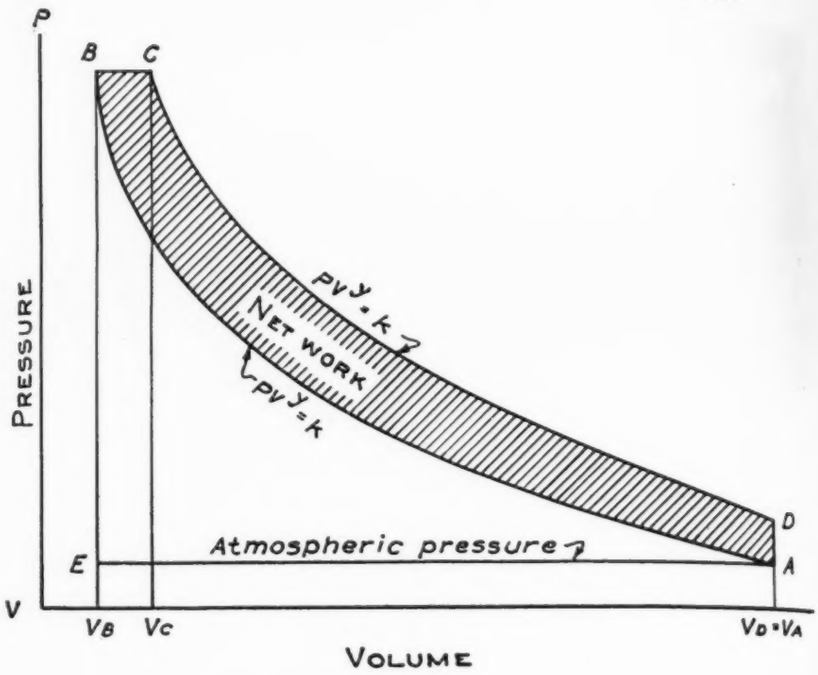
NATIONAL TUBE COMPANY

PITTSBURGH, PA.

United States Steel Products Company, New York, *Export Distributors*

UNITED STATES STEEL

Fig. 1. The theoretical Diesel cycle



Design of 2-cycle engine exhaust more exacting than for 4-cycle engine

Diesel Engine Performance Improved by Better Exhaust Design

By ORVILLE ADAMS

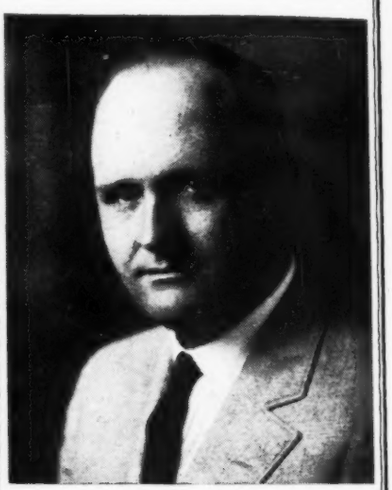
GOOD theory and sound practice dictate a simple and accessible exhaust system for the Diesel engine. The necessary adjuncts are flexible exhaust connections or expansion joints to absorb the strain imposed by expansion and vibration. Silencers are added to insure noiseless operation. Exhaust pits may be used to provide for additional expansion and silencing, and the design and construction of these pits is very important. Whether two- or four-stroke cycle engines are being considered, the engineering of the exhaust system requires consideration of the basic theory of Diesel engine operation and the application of lessons learned from established practice.

The four-cycle engine has a positive and definite means of forcing the old gases from the cylinder through the exhaust valve and into the exhaust manifold and pit as a result of the movement of the piston on its regular exhaust stroke, as is well understood. It is taken for granted that the exhaustion is complete and satisfactory even under adverse conditions, owing to this positive action of the piston. It has been found, however, that the resistance to the outward flow of the gases is excessive if the exhaust pipe is small, if there are many bends in the pipe, or if the exhaust passage is excessively long. The result is that the engine loses power and the temperature exceeds the maximum satisfactory operating temperature.

Back Pressure Defined

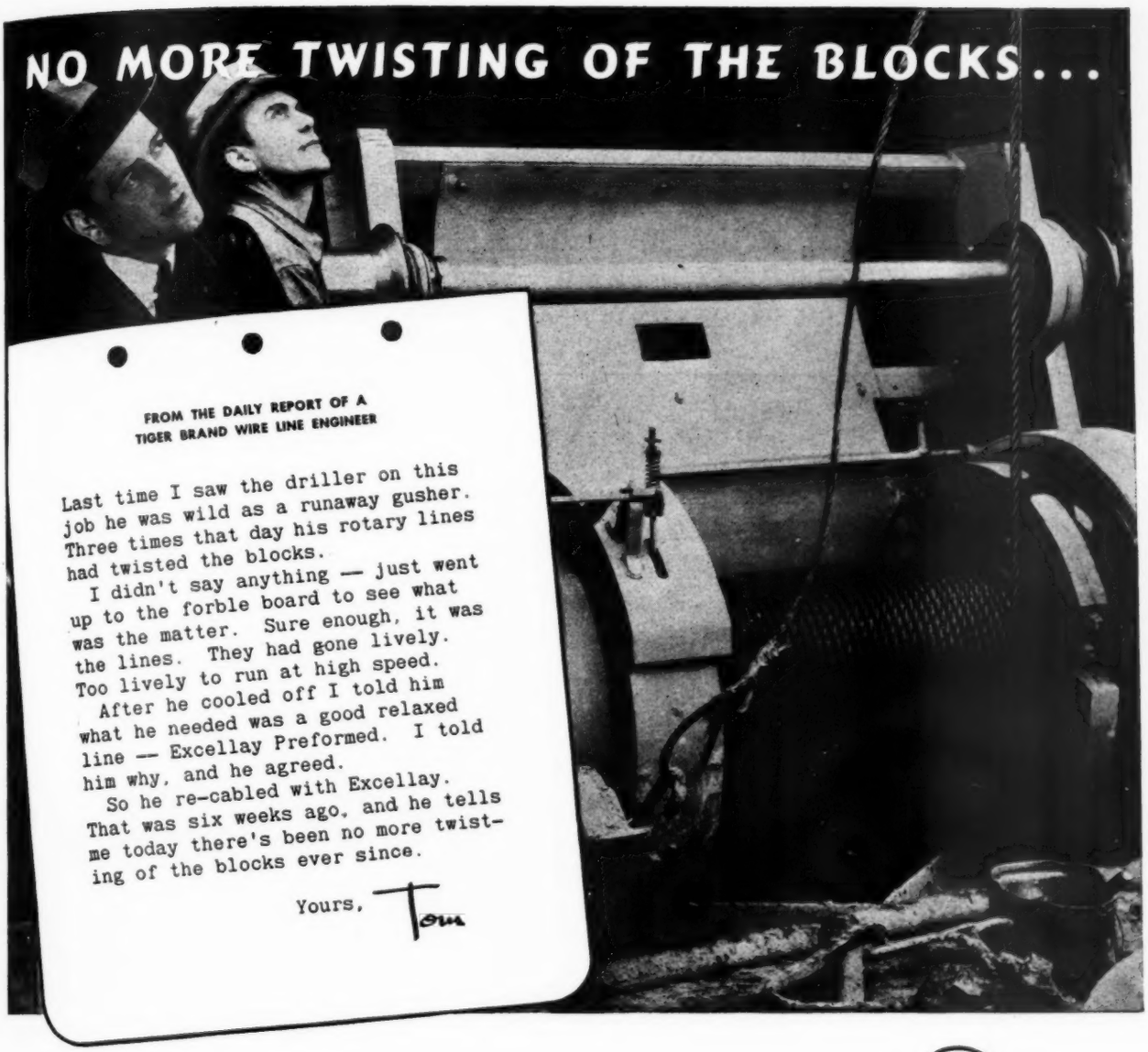
This resistance to the flow of exhaust gases is usually termed "back-pressure". Whatever its cause, it appreciably reduces the normal output of the engine for a given fuel consumption. Other attendant evils are obvious upon analysis.

In the theoretical Diesel cycle as represented by Fig. 1, the exhaust and suction are indicated by lines. The air is drawn into the cylinder along the line E-A, then compressed adiabatically along the line A-B. At B, or along the line B-C, fuel is injected, which is then ignited by the heat of compression. Combustion ensues at such a rate that the heat is absorbed by the air or liberated at the rate required to maintain constant pressure during the early part of the stroke B-C, the combustion of the fuel being completed at C. Thereafter the expansion of the gases is an adiabatic process from C to D. At D, the exhaust valve opens, the gas is released, and the pressure of the spent gases decreases. In this case, it is assumed that no differential pressure is required to discharge the old gases nor to draw in a fresh charge. In actual



ORVILLE ADAMS

was educated at Kentucky State College and served in the technical branch of the army during the World War—After his discharge from the service he was for ten years sales engineer for Diesel engine manufacturers—Since 1930 he has devoted his time largely to the writing of text books and articles for leading technical journals—Is the author of authoritative text books on the Diesel engine that are widely used in technical schools, and at present is preparing a text on Diesel engine thermodynamics for college use—Is also engaged in research and investigation and the preparation of engineering reports on Diesel engine applications.


NO MORE TWISTING OF THE BLOCKS...
FROM THE DAILY REPORT OF A
TIGER BRAND WIRE LINE ENGINEER
Last time I saw the driller on this job he was wild as a runaway gusher. Three times that day his rotary lines had twisted the blocks.
I didn't say anything — just went up to the forble board to see what was the matter. Sure enough, it was the lines. They had gone lively. Too lively to run at high speed.
After he cooled off I told him what he needed was a good relaxed line — Excellay Preformed. I told him why, and he agreed.
So he re-cabled with Excellay. That was six weeks ago, and he tells me today there's been no more twisting of the blocks ever since.
Yours, Tom

NO one could be better qualified to help you get real performance out of wire lines than the American Tiger Brand Wire Line Engineers. These men know exactly what punishment rotary lines have to take in drilling. Putting the right type of lines where they will do the most good is no trick to them, because they spend most of their time doing just that.

The result: You get the most practical wire lines—and what's more you get them in a hurry since complete stocks are available throughout the oil fields. You get wire lines that will give you a full dollar's worth of performance for every dollar of cost.

Be sure to take full advantage of the wide experience of these engineers. They can help you out of many a tight spot, with just the kind of service you need. American Tiger Brand Wire Lines are made in all constructions and grades—every one just as high in quality and technically sound as the men who represent them.

USS

EXCELLAY
Preformed
WIRE LINES

AMERICAN STEEL & WIRE COMPANY
Cleveland, Chicago and New York

COLUMBIA STEEL COMPANY
San Francisco

United States Steel Products Company, New York, *Export Distributors*

UNITED STATES STEEL

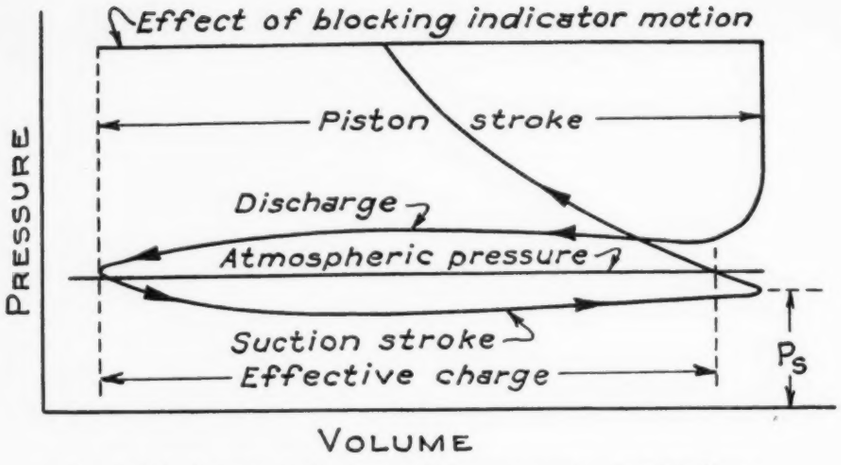


Fig. 2. Weak spring indicator card showing suction and discharge pressure magnified

practice, however, a differential pressure is required to force the gases to flow from the high-pressure area to the low-pressure area, and the exhaust stroke produces the pressure within the cylinder that is needed to force the old gases from the cylinder against atmospheric pressure. Conversely the suction stroke must reduce the pressure in the cylinder slightly below atmospheric pressure in order to cause a charge of fresh air to flow into the cylinder. Fig. 2 shows the effect of this "pumping cycle" formed by the exhaust and the intake or suction stroke as a counter-clockwise line, indicating negative work. Negative work is work done on the gas by the piston, and offsets part of the positive work of the cycle indicated in Fig. 1. This is plainly seen from the equation for work from Fig. 1.

$$W = p_c (v_c - v_b) + \frac{p_c v_c - p_d v_d}{y - 1} - \frac{p_b v_b - p_a v_a}{y - 1}$$

This equation shows that the larger the values of $(v_c - v_b)$ and $(p_d - p_a)$ the more work is done per stroke. Now, v_a and v_b are fixed when the engine size and clearance are selected by the designer, and p_a is the atmospheric pressure or suction pressure. It naturally follows that to produce more work per stroke, v_c or p_d or both must be increased, but the efficiency must be considered.

Referring again to Fig. 2, the area of the "pumping cycle" may be reduced by reducing the resistance to flow of either the intake air or the exhaust or both. This reduction is usually accomplished by the use of larger pipe, fewer bends or turns, turns of longer radius, and shorter inlet and exhaust systems, and by keeping the air filter and the muffler and exhaust passages clean, all of which are effective means of reducing the pumping losses. These pumping losses, whether the result of back pressure or restricted air intake, reduce considerably the efficiency of the engine. The engine may discharge only 85 percent instead of 90 percent of the old gases. This would mean that the engine suffers reduction of efficiency somewhat as follows:

1. Fresh air, 85 percent instead of 90 percent.
2. Hot gases left in the cylinder to mix with the incoming air, 15 percent instead of 10 percent.
3. More fuel would be required to do the work required to overcome the increased pumping losses.

The net results of excessive back pressure in an exhaust system are greater fuel consumption, operation of the engine at higher temperature, and additional stresses to obtain a given power output.

Requirements for Exhaust Pipe Sizes

For the four-cycle engine, engineers usually specify the exhaust pipe size for a definite pipe length and number of turns, and state the additional requirement that pipe one size larger must be used if the length of the system exceeds 24 ft. of pipe. As an illustration, if the length of the pipe does not exceed 24 ft. and there are not more than two bends, a 7-in. pipe can be used. If the length and number of turns exceed these limits, 8-in. pipe must be used.

Inclusion of the underground pit in the exhaust arrangement has definite advantages under certain conditions. These pits must be adequate in size and placed near the engine if they are to relieve back pressure appreciably. Such a pit constructed of concrete or metal, about which is packed dirt or sand, has a dampening effect on the high-pitched exhaust noises. The underground pit is obviously more convenient than the large exhaust pots or drums, being out of the way of the operators and of equipment such as cranes.

Two-Cycle Exhaust

There are two classes of the two-cycle engine, which must be considered separately: (1) the crankcase scavenging type, in which the scavenging pump is the lower side of the engine piston, and (2) the pump or blower scavenging engine, in which a separate cylinder or blower is employed to supply the scavenging air.

The two-stroke crankcase-compression type has no mechanical or friction losses other than that which is common to any type of piston, namely, piston friction. Its chief limitation is that its scavenging displacement is limited to that of the engine piston. The separate-scavenging type, having a special pump cylinder or blower, may have a displacement much greater than the piston displacement of the engine, but such an arrangement involves mechanical losses due to the added mechanism.

The volumetric efficiency of the crankcase scavenging engine will be 60 to 75 percent under average conditions. That is,

$V_s = (.60 \text{ to } .75)\ V_c$

wherein

V_s = volume of scavenging air delivered

V_c = volumetric displacement of the engine piston.

Under this condition, a piston having a displacement of 1 cu. ft. (12 in. by 15½ in.) would be supplied with only .60 to .75 cu. ft. of air, and a portion of that usually passes through the exhaust ports at the time of scavenging, and therefore does not support combustion.

On the other hand, the pump or blower scavenging unit is designed with a volumetric displacement of at least 1½ times the engine piston displacement, and hence has a volumetric efficiency of 80 to 90 percent. The crankcase volume is very much out of proportion as clearance space for the piston, but the air pumps and blowers used for this specific service are not handicapped by such a clearance volume, and will give a satisfactory volumetric efficiency. In these engines the pump volumetric displacement, V_p, is as follows:

$V_p = (1.3 \text{ to } 1.7)\ V_c$ and,

$V_s = (.8 \text{ to } .9)\ V_p$, hence,

$V_s = (.8 \text{ to } .9)\ (1.3 \text{ to } 1.7)\ V_c$

which means that the net quantity of scavenging air delivered to the cylinder is 1.15 to 1.40 times the engine piston displacement. This makes possi-

(Continued on Page 82)

k 800 HP "Angle"

for BOOSTER STATION SERVICE

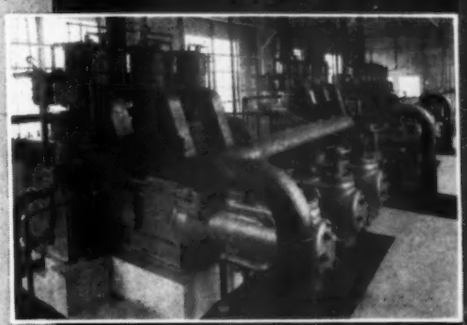
Five CLARK 6-cylinder, 600 H.P. "Angles", Wilmot, Ark., Booster Station of Memphis Natural Gas Co.

The spectacular success of the higher-speed CLARK "Angle" Compressor, in gas booster station service, has led to a demand by gas pipe line companies for this compressor in an 8-cylinder, 800 H.P. size—to secure maximum station power in a given floor space. Note the diagram of a 3,200 H.P. plant. The compact design of the CLARK "Angle", its higher speed, and the fact that it is now available in the new 8-cylinder size—render it possible to install this 3,200 H.P. plant in a floor space of only 24x105 feet.

CLARK 600 H.P. "Angle," Colorado Interstate Gas Company, Channing, Texas.

The world-wide success of the CLARK "Angle", achieved in less than three years, is attributable directly to the following important savings which it has introduced:

1. REDUCED TRANSPORTATION AND ERECTION COSTS, because it is shipped practically assembled.
2. SMALLER FOUNDATION, FLOOR-SPACE, BUILDING, because of compact right-angle design.
3. FUEL SAVING, due to CLARK Super-2-Cycle Fuel Injection.
4. LOWEST MAINTENANCE, due to extreme simplicity of design, and few parts.



Two 3-cyl. and one 6-cyl. CLARK "Angles," Rochester Pipe Line of Godfrey L. Cabot, Inc., Genesee, N. Y.

Get in touch with our nearest office. Further details in Composite Catalog.

CLARK BROS. COMPANY . . Olean, New York, U.S.A.

Export Office: 30 Rockefeller Plaza, New York. Domestic Sales Offices and Warehouses: Tulsa, Okla.; Houston, Texas; Chicago, Ill.; Boston, Mass. (131 Clarendon St.) West Coast Office: Smith-Booth-Usher Co., Los Angeles, Cal. Foreign Offices: 72 Turnmill St., E. C. 1, London; 4 Str. Gen. Poetas, Bucharest, Roumania.

CLARK

GAS LINES EQUIPPED WITH CLARK "ANGLE" COMPRESSORS

Colorado Interstate Gas Co.
Memphis Natural Gas Co.
Carnegie Natural Gas Co.
Mississippi River Fuel Co.
Godfrey L. Cabot, Inc.
Birmingham Gas Co.
Washington Gas Company
Southern Union Gas Company
Long Island Lighting Co.
Penn York Gas Co.
New Mexico Gas Co.
Hanley & Bird Co.

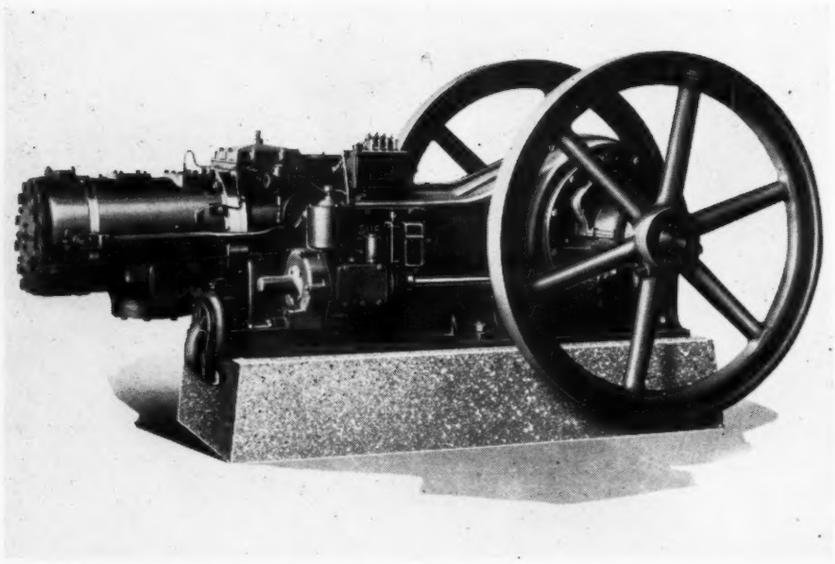


Fig 3. A 2-cycle engine of the crosshead type is not so sensitive to change in the exhaust piping as is the crankcase scavenging type

(Continued from Page 78)

ble almost complete scavenging, virtually none of the old gases being left in the cylinder, and at the same time provides surplus air. It is true that some of this surplus air escapes with the exhaust gas, but one of the principal functions of the surplus air is to assist in cooling the engine piston and the cylinder. Any well-designed pump-scavenged type of engine will have a scavenging efficiency ranging upward from 90 percent, which equals or actually exceeds the scavenging efficiency of the four-cycle engine.

Supercharged Engines

The pressure of the scavenging air supplied by the pump or blower ranges from 1 to 5 lb. gauge, most engines receiving air at 1.5 to 3.5 lb. When it is desired to supercharge, provision is made for trapping a portion of the air after the escape of the exhaust gases. In such engines pressures of 3 to 7 lb. are required for scavenging or supercharging air.

The pump or blower scavenged engine is not quite so sensitive to exhaust piping arrangement as the crankcase scavenged engine. An unusual resistance in the exhaust line causes the exhaust temperature to rise somewhat, and the pressure will likewise rise slightly. A pressure gauge having a scale range of about twice the normal pressure is connected to the scavenging air header. These gauges are graduated from 0 to 5 lb. by ½-lb. increments. If the engine normally operates on scavenging air at 2 lb., any change in this pressure is a matter of concern to the operator. Any increase to, say, 2¼ lb. generally indicates obstruction in the exhaust passage. A decrease, on the other hand, say to 1¾ lb., indicates a dirty air filter, stuck valve on the pump, or some trouble on the fresh air side of the cylinder. Changes in the air temperature and barometric pressure will result in slight changes in the scavenging air pressure, assuming that other conditions remain constant. Any definite change in the engine load affects the scavenging air pressure also, but most such pressure variations will be less than 5 percent of the normal pressure, and may escape observation altogether if the gauge is not of the proper dial type. Operators in many plants are required to record their observations of this pressure periodically.

The crankcase scavenging engine is highly sensitive to changes in the exhaust system. Inasmuch as the scavenging air pressure is relatively low, from 0.5 to 1.5 lb., and a part of the scavenging effect is caused by the "slug" or mass of the exhaust gas acting as a piston, the conditions of the exhaust of this type of engine cannot always be correctly analyzed. This behavior of the exhaust action of the two-cycle engine is not fully appreciated by the average operator. It is not necessarily a function of the pressure that can be measured by a manometer or other instrument capable of measuring small variations in pressure. There is evidence to indicate that the exhaust is affected by sound waves operating within the exhaust pot, exhaust pit, or pipes, which might be desirable in a four-cycle engine, but may prove very harmful in the two-cycle engine.

The sensitivity of the two-cycle engine to changes in the exhaust arrangement is well illustrated by one Diesel engine that requires a 10-in. exhaust pipe 12 ft. long or 28 to 30 ft. long. It was found that the engine operates satisfactorily on either of these arrangements.

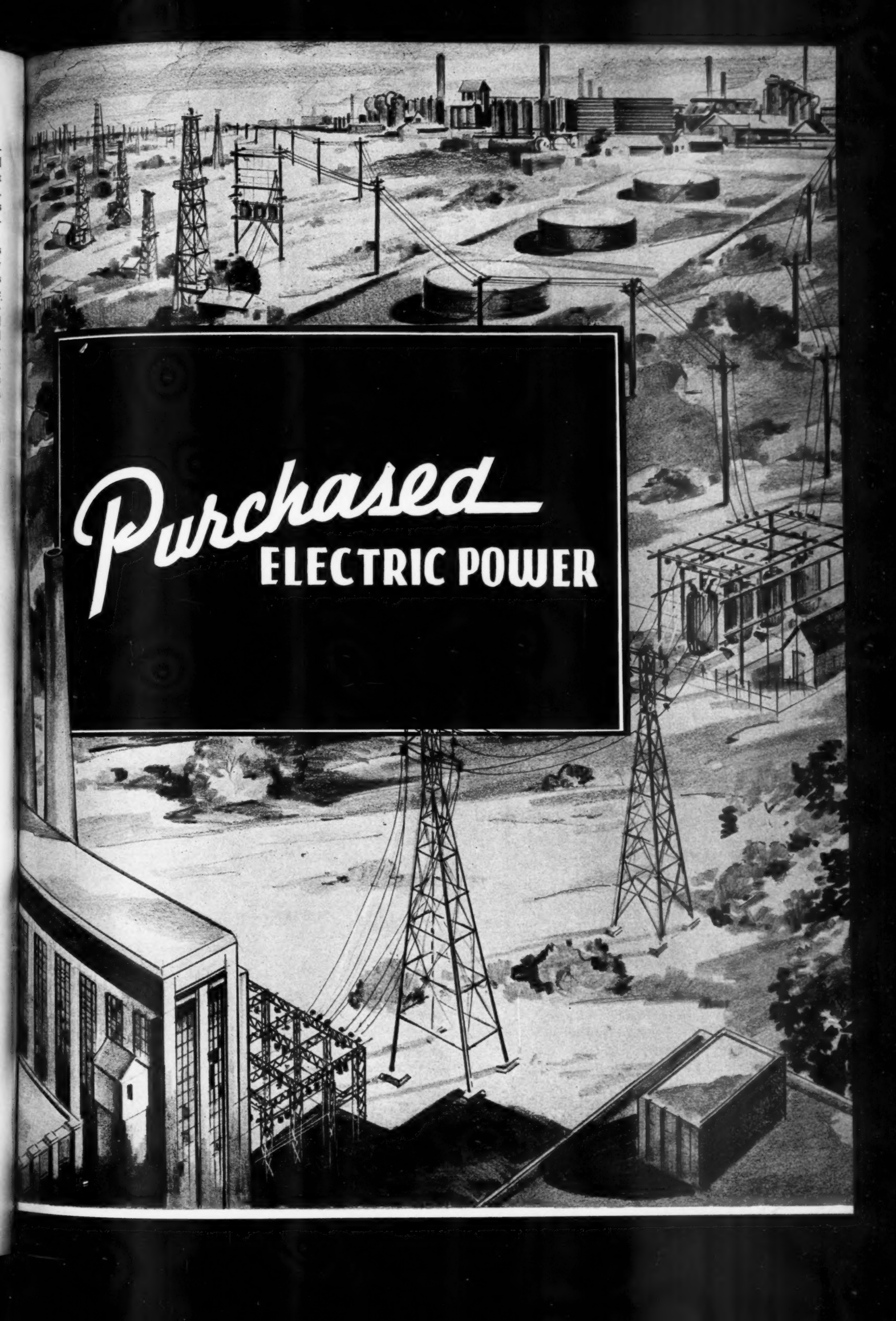
The same engine overheats and is unable to pull its rated load when any intermediate length of exhaust pipe is used. The 10-in. by 12-ft. pipe is quite satisfactory, but when a 12-in. by 12-ft. pipe was used, the engine would pull only a small fraction of its rated load. The manufacturer of another two-cycle engine found by experiment that the engine was affected by changes in the length of the exhaust pipe as follows:

Pipe length	Percent of rated hp. developed
Less than 42 ft.	Less than 25 percent
46 ft. to 47 ft.	110 percent
52 ft. to 53 ft.	Less than 60 percent

It has also been found that although the exhaust system is satisfactory at one speed, it may be very unsatisfactory at another speed as much as 10 percent above or below the rated speed. If the exhaust system of a two-cycle engine is satisfactory when the engine speed is 327 r.p.m., the system would be questionable at 300 r.p.m. and very unsatisfactory at 277 r.p.m. A change in engine speed will not always require a modification in the exhaust piping, but is likely to necessitate a change.

A departure from the manufacturer's recommendation is not advisable. Attempts to improve operation by using larger pipe, shorter pipe, larger pits, or many other modifications usually result in unsatisfactory operation.

Many of the two-cycle engines are the crosshead type, and do not make use of the crankcase for scavenging air. In these engines there is a scavenging chamber directly behind the piston, the piston rod passing through a partition fitted with a packing gland. Engines of this type are numerous in the oil fields, where they are used for pumping and pipe-line service. Such engines are usually single-cylinder or twin-cylinder designs in sizes ranging from 30 to 300 hp. They require little head room and are convertible to operation on gas or oil. This type of engine compresses its scavenging air to a pressure of several pounds, usually 6 to 14 lb. pressure. The general operating characteristics are about the same as those of the vertical two-cycle engine using crankcase compression and scavenging. A particular advantage, however, is that this type is not so sensitive to change in the exhaust piping as is the crankcase scavenging type.


Purchased
ELECTRIC POWER

P 615.511
P 941.4

Estimating Power Requirements

By

E. A. ARMSTRONG

Public Service Company of Northern Illinois

GRANTED that many pieces of equipment will have a physical life of twenty years, their economic life is ended when their efficiency on the job for which they were purchased begins to drop seriously.

Up until ten years ago, the big steel companies made all their calculations for new power-plant equipment on the basis that it would be used continuously on full-time operation for a life of 20 to 30 years. When they figured their unit costs on this basis, it resulted in low hp-hr. costs that later were found impossible to attain.

During the twenties we were just at the beginning of the "new era" and "everything was going to operate at 100 percent load factor"—that is, full operation 720 hours per month. One member of the steel production group decided to investigate how they really had operated since the war, with respect to this 100 percent operation basis. It was found that in many of the 120 months of the previous ten years, the steel plants had operated on less than a 50 percent basis, and in other months operations had been less than 75 percent. Experience and calculations began to reveal the economies of purchased power. In the years since, steel companies have turned generally to that source of power in planning new construction.

Ten years ago, oil companies asserted they could generate power at a low cost per kw-hr. This assertion was based on an assumed 20-year life for a power unit and an annual load factor of 85 percent or better.

It may be true in a few cases, that the assumed load factor is maintained and the original estimate thereby approached, provided all the other assumptions are correct; but a difference in actual load factor from that assumed, even part of the time, generally wipes out the hoped-for savings and may even result in a big loss when figured over the entire 20-year life originally assumed.

E. A. ARMSTRONG

was educated at Michigan State College, receiving degree in electrical engineering—With Continental Utility Company as construction engineer and division manager—Michigan State College as assistant professor of physics—Lincoln Motor Company as assistant superintendent of construction and maintenance—Public Service Company of Northern Illinois as manager power sales—Is a member of American Institute of Electrical Engineers, Western Society of Engineers, Electric Association of Chicago, American Petroleum Institute, and Petroleum Electric Power Club.

An increase in load may destroy the hoped-for economy as effectively as a decrease in load. Preparation for the increase may create an investment so high during this preparation period prior to the increase in load that the excess capital charges will offset any apparent saving. This increase in investment may be represented by added land requirements, added cooling-water facilities, provision for extra building site, perhaps additional space in the building itself, and others of the many items that must be included in a plan to build in advance of expansion.

It is so easy to err by basing the efficiency calculations on an assumed load-factor to obtain an answer to the question of what type of power should be used. Then, as the design progresses and the need for future additional capacity becomes apparent, additional expenditures may be authorized without re-calculating the effect of this change on the overall efficiency of the plant.

In many cases, if the actual operation could be forecast, it is probable that the flexible electric-power supply from a central station would be the most economical over the entire period. This is because the customer can "choose the size of his power plant." He can change his demand, once each year in most contracts; in some, he can actually change his demand on a monthly basis. This flexibility applies more than ever, because today the network of utility lines in certain areas has reduced the length of line exten-

Twenty Years Ahead Hazardous

Conditions in petroleum industry change so rapidly that long-range forecasts of operations cannot be made with assurance

sions and the amount of guarantee required in many localities.

A review of the history of a group of pipe lines covering the last ten years, which is only half of the 20-year life, disclosed some interesting facts on the utilization of operating capacity.

In one instance operations had been at a low ebb for several years of the ten, yet for a few months during that period, had the system been electrified, electric power service could have been called upon at a time when increased capacity was needed in amount that did not justify starting-up big plants that had been shut-down.

Another system has a problem of continually increasing capacity. It has now reached the point that with increments of 300 or 400 hp. the load factor is such that electric power could be purchased at rates that would equal the hoped-for economies of other power.

Another pipe line system has operated almost continuously at a high load factor, very near the probable contemplated load at the time it was designed. Plans are being made to pump through this line other types of products than that for which it was designed. This change alters materially the hydraulic power requirements. The expired life of the line is ten years, or half of its total assumed life.

Constantly-changing conditions in the oil industry make long-time forecasts hazardous.

The changes in sources of crude supply have materially changed the operating methods of another pipe line. A reduction in capacity through one part of its line and an increased flow in an opposite direction on a branch is an indication of how hopeless it is to forecast 10 or 15 years in the future. This sets up an ideal illustration of the advantage of low investment, "pay-as-you-go" type of power service, which does not depend on a 20-year life to make it profitable. Although the apparent monthly outgo may appear higher than was originally planned when re-figured on a ten-year basis, the flexible power supply may show considerable saving.

Perhaps there are instances in which business has remained static and the theoretical load factor has remained close enough to the estimated figure to show at least an even break, but such cases are few and far between. Any business that is static for ten years is a "dead" business. No one who knows the oil business would classify it as a "dead" business. In fact, the oil business has changed rapidly the last ten years in all its branches, production, transportation, and refining. There are really very few businesses that can foretell their power requirements five years ahead, to say nothing of foreseeing ten or twenty years ahead.

Refineries have been going through changes in ratios of steam requirements against power requirements and unsalable by-products against power requirements very rapidly the last few years. If these conditions could have been foreseen, the question of power supply and attendant difficulties arising from the wide fluctuations in energy demand, would in many instances have been turned over gladly to someone else.

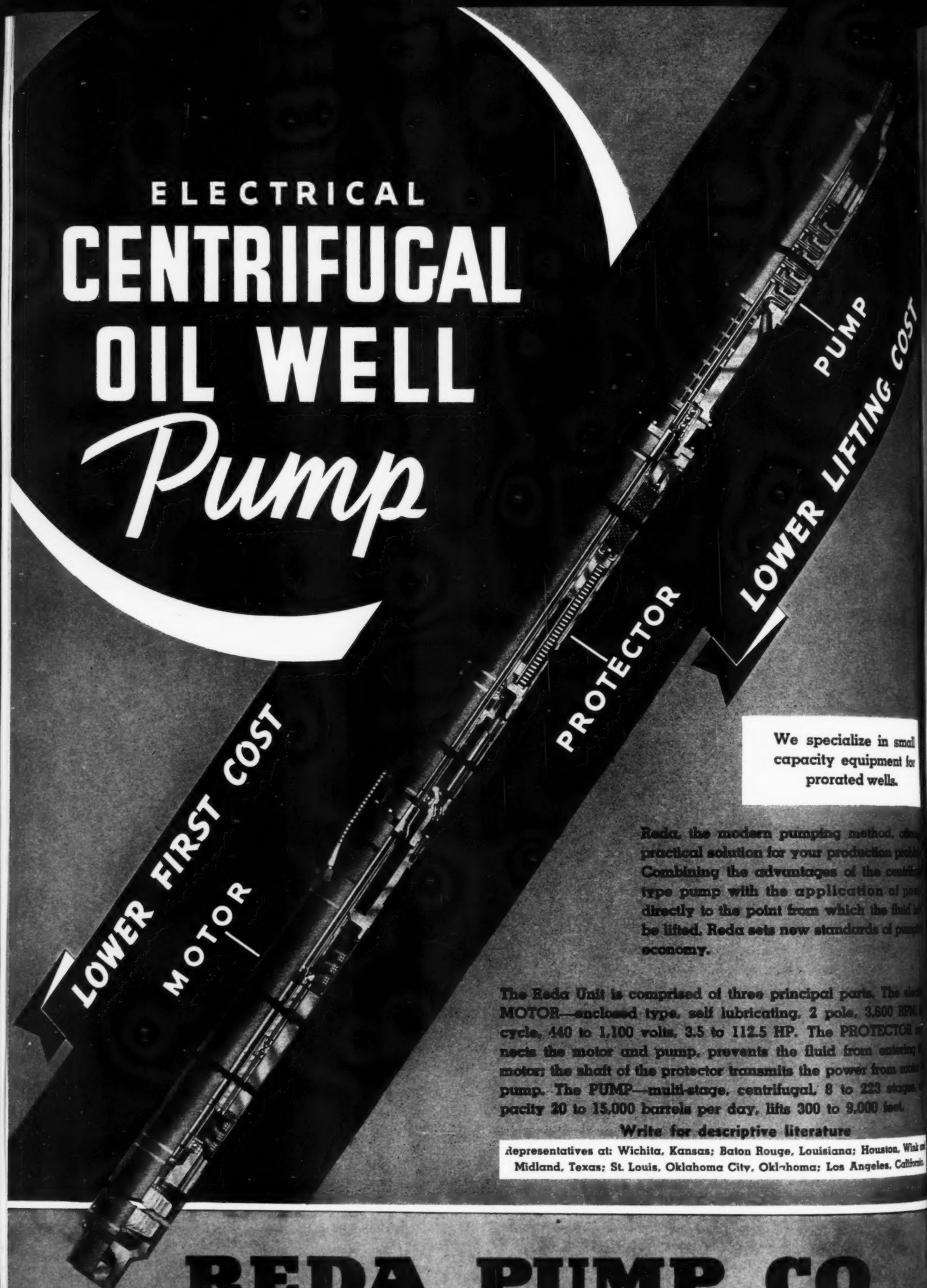
PURCHASED electric power is playing an increasingly important role in the petroleum industry. Evidence of this is the yearly increase in the amount of energy of this type that is being used. Accounting for this increase in the application of electric power to drilling, producing, transportation, and refining operations are several factors. Among these are its greater availability and a recognition of the adaptability of electric power for certain operations. In use it is efficient and economical. Recent development of processes are dependent in large degree upon electric power.

Some factors contributing to the adoption of electric power are interdependent. For example, as operators have realized a need for electric power to serve a specific purpose, transmission lines have been extended to supply their requirements. This, in turn, has made electric power readily available to other possible users and by its accessibility has made many of them actual users. Purchased electric power for many years has been utilized for pumping wells, for pipe-line pumping on trunk and gathering systems, and for numerous operations in the refinery. In recent years greater utilization has been made of electrical energy in water-flooding operations for the increased recovery of oil. Another recent important process in refining, desalting and dehydrating of crude oil, is dependent largely on electrical power for operation and control. Of still more recent development are the catalytic processes of refining, the successful development of which has been made possible by the close control that electrical equipment provides.

The group of articles in this section is presented to convey to our readers a picture of the application and availability of purchased electric power in the petroleum industry.

ELECTRICAL

CENTRIFUGAL OIL WELL *Pump*



We specialize in small capacity equipment for prorated wells.

Reda, the modern pumping method, offers practical solution for your production problems. Combining the advantages of the centrifugal type pump with the application of power directly to the point from which the fluid is to be lifted, Reda sets new standards of pumping economy.

The Reda Unit is comprised of three principal parts. The electric MOTOR—enclosed type, self lubricating, 2 pole, 3,600 RPM, 60 cycle, 440 to 1,100 volts, 3.5 to 112.5 HP. The PROTECTOR connects the motor and pump, prevents the fluid from entering the motor; the shaft of the protector transmits the power from motor to pump. The PUMP—multi-stage, centrifugal, 8 to 223 stages, capacity 20 to 15,000 barrels per day, lifts 300 to 9,000 feet.

Write for descriptive literature

Representatives at: Wichita, Kansas; Baton Rouge, Louisiana; Houston, Wink and Midland, Texas; St. Louis, Oklahoma City, Oklahoma; Los Angeles, California.

REDA PUMP CO.

BARTLESVILLE, OKLA.

THE ONLY SUBMERGIBLE ELECTRICAL CENTRIFUGAL OIL WELL PUMP

P 516.9
P 615.511

An Economic Study of Electric Power in Oil-Well and Pipe-Line Pumping Service

Past performance records of oil-producing and pipe-line companies valuable in determining the merit of generating own electric power or of purchasing electric power for operations

By W. H. STUEVE

Oklahoma Gas and Electric Company, Oklahoma City, Oklahoma

EXPERIENCE gained in years of active contact with both oil producers and oil pipe liners, pointing out to them the advantages of using purchased electric power, has shown the value of a detailed study of past performances of actual motor installations in production and pipe-line service.

The primary reason for making these investigations and analyzing past performance records was to verify or disprove the belief of many executives and engineers of oil companies that "their power costs are constant and uniform throughout the years of operation". It is easily understood how this conclusion is reached in many instances by these men when it is realized how few important elements are considered when a decision involving a choice of power must be made.

The chain of events in making a decision concerning source of power is sometimes no more extensive than this: The engineer, faced with a need for power to perform certain operations, prepares and presents to the executive a report that may, unfortunately, be based only on present conditions and with little thought of the future. The executive accepts the report and presents it to his banker, who arranges for the required cash outlay.

In modern business every authority, every text-book on accounting or engineering economics, even many court decisions in valuation cases, is stressing the soundness of including *all* items of fixed expense as a part of the cost of doing business. In the face of this, it is amazing to find so many operating companies flagrantly violating this rule in the economic study of the power problem. The items of depreciation, depletion, and obsolescence, among others, are not charged against the equipment as a part of the operating expense. Consequently, the engineer and executive may be satisfied with the apparent showing, but the actual cost of power may never be revealed to them or to the outside world.

W. H. STUEVE

received both mechanical and electrical engineering degrees from Ohio State University—Is a member of the Oklahoma State Board of Registration for Professional Engineers—Member of the American Society of Mechanical Engineers and the American Petroleum Institute — For the last 15 years he has been associated with the Oklahoma Gas and Electric Company, having charge of oil-field, pipe-line, and refinery electrification.

To illustrate the factors that influence the amount of power required for oil-field operations over a period of years, Fig. A is submitted showing the volume of oil in bbl. produced annually from some of the principal oil fields in Oklahoma from 1929 to the middle of 1938. Production from the fields has been influenced by proration and general economic business conditions, yet it is evident that depletion plays an important, if not the greatest part in the production decline indicated. In 1937 the productive areas of Oklahoma City, Fitts, Edmond, and Lucien fields were definitely defined and drilling operations ceased. The rapid decline in production from these fields in 1938 may be attributed, therefore, largely to depletion of the oil reserves. This picture of depletion in the Oklahoma fields is more or less

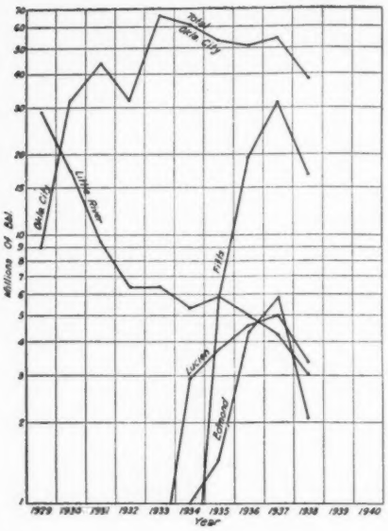


Fig. A. Bbl. of oil produced in Oklahoma fields during last 12 years

typical of the eventual decline that oil fields in other states must suffer.

Natural decline of production in oil fields not only affects the pipe-line industry, but also is a major factor affecting the producing industry because it prescribes that well-pumping equipment can not operate at high capacity rates over the entire life of the particular field being studied.

Power for Pipe Line Pump Stations

To illustrate the probable amount of use of equipment installed in pump stations to serve a typical oil field, Fig. B has been prepared to show the operating history of five stations installed in the Oklahoma City field over the ten-year period 1929 to 1938. The average annual percent utilization of the equipment for each station is shown for each year. The capacity of these five electric pump stations represents almost 60 percent of the total capacity of all pump stations serving the entire Oklahoma City field.

The percentages shown as annual averages were obtained by adding the monthly percentage values of equipment utilization in representative months and dividing by the months studied. Actually the monthly utilization approached 100 percent only during several months of the ten-year period.

TABLE I

Approximate energy purchased, oil pumped, and operating cost on station investment for five pump stations in Oklahoma City field for the ten-year period, 1929 to 1938.

Horsepower	Average percent utilization of capacity	Average percent capacity factor	Total electric energy purchased kw-hr.	Total oil pumped, bbl.	Cost in cents per bbl per 30 miles*	
					Actual cost of electric operation	Estimated cost† of engine operation
1200	8	18	6,330,000	42,600,000	1.16	1.32
900	44	58	34,800,000	85,500,000	0.42	0.46
500	54	67	15,600,000	61,200,000	0.23	0.25
400	42	57	11,200,000	45,800,000	0.44	0.48
200	30	45	3,780,000	19,700,000	0.59	0.75

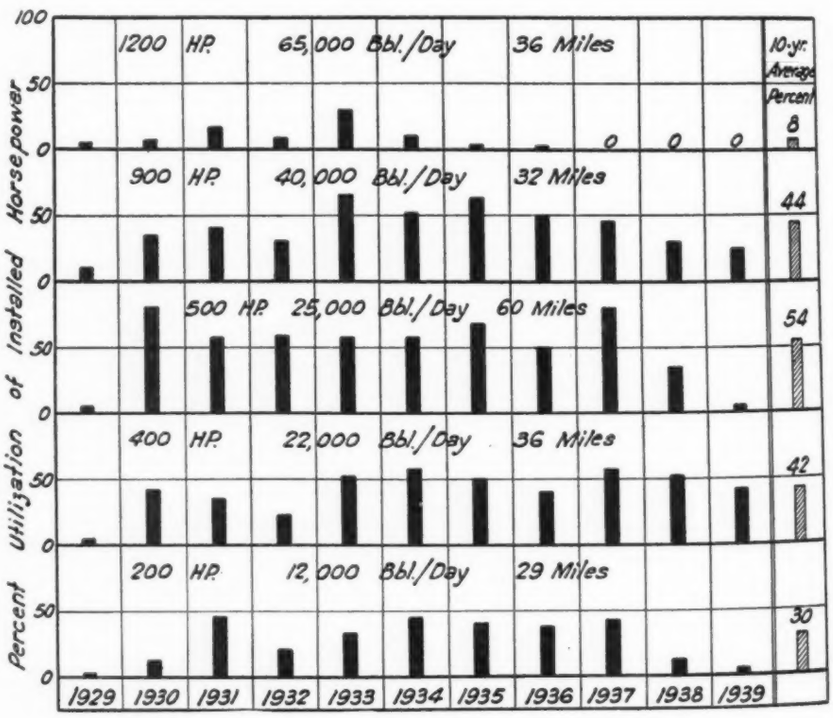
*Customary average design distance between stations.

†Estimated cost comprises: maintenance.....$2.00 per engine-hp. per yr.
fuel..... 1.00 per bbl.
fixed charges..... 13 percent per yr.

The horsepower rating of the motors installed in each station was based on the stated pump capacity in bbl. per 24-hr. day at an operating pressure of 750 lb. per sq. in. It should be pointed out that the percent utilization of maximum capacity is not a true indication of the actual volume of oil pumped because in some of the stations there were several stand-by motors and pumps installed and even in the stations containing only one motor operating a duplex or a triplex plunger pump, one plunger, in some instances, had been blanked-off to reduce the volume pumped. An empirical method of determining the relation between percent utilization of motor capacity and volume of oil pumped can be expressed thus: Percent utilization of capacity equals (oil capacity factor)$^{1.5}$.

In Fig. B it will be noted that the ten-year average utilization of maxi-

Fig. B. Ten-year operating record of five electric pump stations serving the Oklahoma City oil field. These stations total 3200 hp. having a capacity of 164,000 bbl. per day



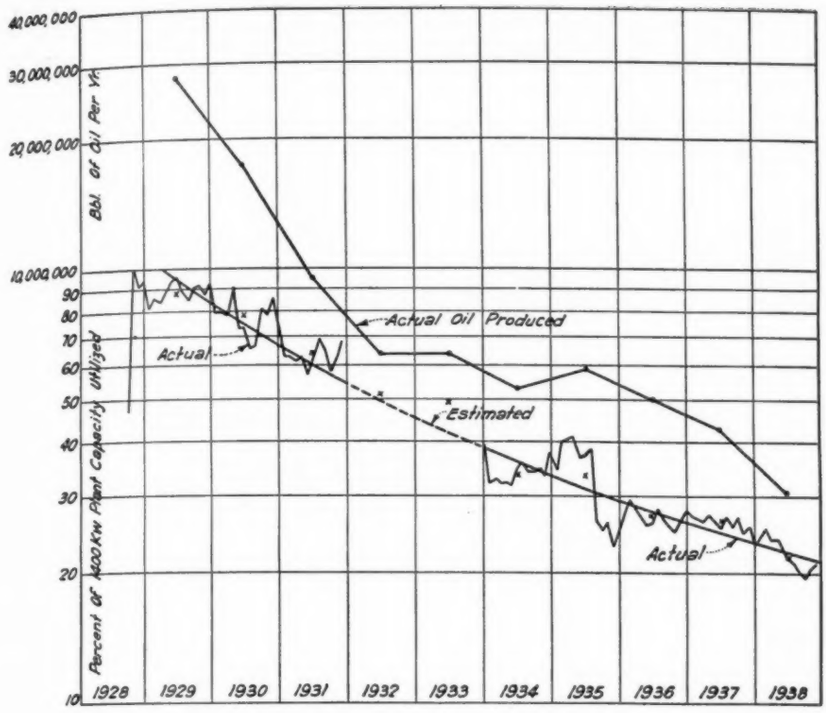


Fig. C. Volume of oil in bbl. produced annually from 1929 to and including 1938 in Little River pool, Oklahoma; and electric power generated by one large operator

mum capacity for the five stations never exceeded 54 percent and actually fell as low as eight percent in the largest (1200-hp.) station. It can be noted further how the utilization of capacity fell off during 1938 and 1939 in all stations operating after 1937, the year the Oklahoma City field was at its peak. The Oklahoma City field produced 54,000,000 bbl. in 1937 and only 38,500,000 bbl. in 1938. Thus, percent utilization in pump stations of capacity installed to serve peak conditions in a given field may be said to follow closely the variations in production from the entire field.

From Fig. B the actual amount of energy purchased can be computed and, likewise, the amount of oil handled can be ascertained. These values are shown in Table 1.

It may be noted in Table I that the spread between engine operating cost and electric-motor operating cost becomes less as the capacity factor increases up to about 70 percent. From other data, it has been determined that at capacity factors above 70 percent, cost of engine operation becomes equal to or slightly lower than that of electric-motor operation. If design engineers could be certain that a capacity factor of 70 percent or more would be maintained for a long period of time, say ten years, the choice in selection of prime mover equipment would be clearly indicated. The record of ten years' operation of the stations presented in Fig. B shows, however, that in only two years, 1930 and 1937, in only one pump station (the one containing the 500-hp. motor) was the capacity factor high enough to indicate that engines might have been operated at no greater unit cost than electric motors.

The probable utilization of pump stations installed on a line transporting oil from a specific field is as much affected as that of other types of equipment in the oil industry by laws of supply and demand and the fluctuations of general business conditions throughout the country. These uncertainties contribute to the probability that the capacity factor over a ten-year period may rarely exceed 60 percent and may be as low as eight or ten percent.

Power for Oil-Well Pumping

It is generally conceded that beam pumps have been used to lift perhaps 90 percent of the total oil produced after the reservoir pressure has been reduced below the value at which production by natural flow may be obtained. When beam pumps are employed gas engines are usually selected as prime-movers in order to utilize as fuel the natural gas produced with the oil. The marketable value of the gas frequently may govern the selection. More recently, however, electric-motors as prime-movers for beam pumps have been adopted in many instances. In the Fitts field, Oklahoma, electric-motors driving beam-pumps have been installed on nearly one-half of the pumping wells. In the new Illinois development, 3-hp. and 5-hp. motors have been installed to power perhaps 60 percent of the pumping wells.

For the purpose of discussing the selection of power for oil-well pumping it will be assumed that electric motors have been selected to actuate the beam pumps and that the necessary electric power may be obtained either by generation on the lease or by purchase from a power company.

In the choice of the electric-power source, several factors must be considered. Some of the more important variables may be enumerated as follows:

(a) Size and characteristics of the contemplated load.

(b) Nature and amount of fuel available and its cost or value.

(c) Possibility of water encroachment in the producing horizon.

(d) Probable decline of production in the specific oil field.

The consideration of load size under (a) may be simplified if power-generation is decided upon by applying the general rule of selecting steam-turbines to drive the generators when the load is 3000 kw. or greater. Loads of 1500 to 2000 kw. may be generated more

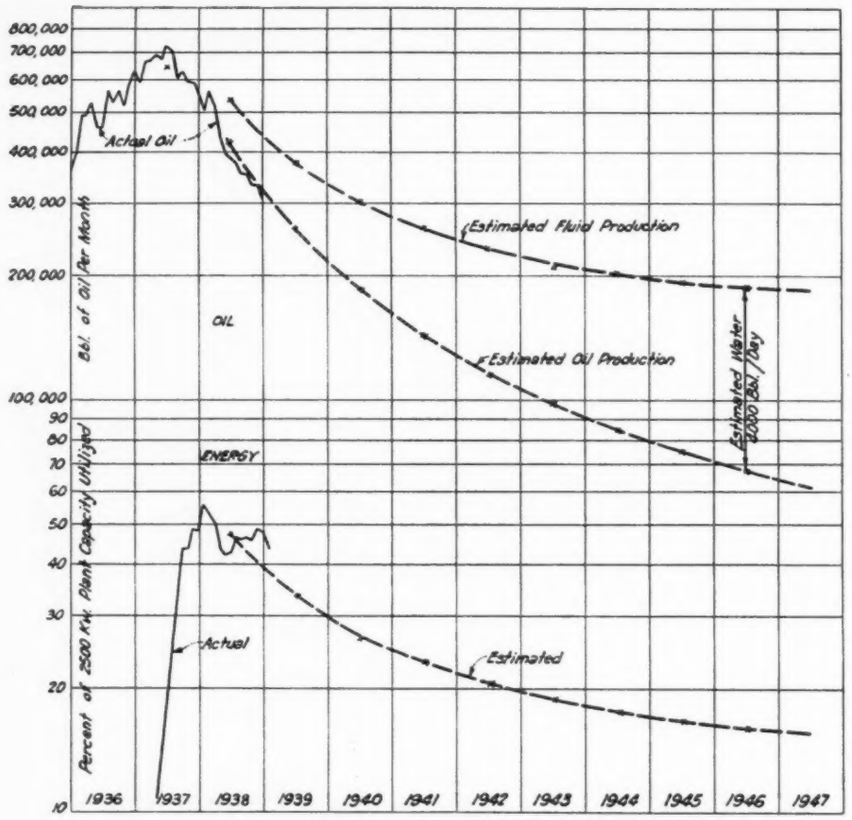


Fig. D. Volume of oil and fluid in bbl. produced by one company during 1936, 1937, and 1938, and estimated production through 1947 (upper part of chart). Energy generated during 1937 and 1938, and estimated requirements through 1947 (lower part of chart)

profitably by internal combustion engines.

(b) Natural gas usually is a by-product of oil production in most fields, generally considered to have no market value. In some instances, however, particularly in the latter years of a field's life, the volume of gas may become insufficient so that fuel and its cost may eventually enter as a major item of cost in generating-plant operation.

The gas requirements of repressuring programs that may be employed in the later life of most fields must be considered in estimating the amount of natural gas available for engine fuel and its economic worth at that time.

(c) The probable amount of salt water that must be pumped per bbl. of oil produced is an important factor affecting estimates of future pumping loads and costs.

(d) The probable decline of production is difficult to estimate accurately. After the flush oil of a defined field has been produced, its productive capacity generally levels-off at some fairly constant value. What this capacity may be is difficult to forecast.

For one reason or another, whether it be lack of market, normal decline, or proration, production from oil fields is subject to influences that tend gradually to reduce the amount of oil that can be produced profitably.

The general study of the decline in productivity of oil fields led to further study of conditions in certain oil fields where power generating-plants either were installed, or their installation was being considered, to provide power to motor-operated beam-pumping units.

The two most interesting power plants included in the study were (1) a 2000-hp. plant in the Little River field, Oklahoma, installed in 1928 and (2) a 4000-hp. plant in the Fitts field, Oklahoma, installed in 1936. These plants were installed to procure electric power in what was believed to be the most economical manner and estimates indicated a long, useful life for the generating equipment. It was recognized that the volume of oil production would decline, but anticipated water encroachment and the necessity of pumping an increasing volume of water in the final stages of production was expected to provide the generating plant with a full load during its entire economic life, even though the cost per bbl. of oil would increase considerably.

To test the economics of this plan, records of oil production and generating-plant energy output have been analyzed in the plants in both the Little River pool and the Fitts pool. Fig. C shows the volume of oil (in bbl.) produced annually from 1929 to and including 1938 in the Little River pool. The amount of water produced is unknown. Note the decline over the ten-year period. Directly below the oil production curve is shown in terms of "percent maximum capacity" the actual electric power output of the 1400-kw. generating plant, both by monthly and yearly averages. The plant's average annual capacity factor decreased gradually from 87 percent in 1928 to 22 percent in 1938. The volume of oil produced in 1938 is about ten percent of the volume produced in 1928. From this it may be assumed that the volume of water produced in 1938 by the wells supplied with power from the Little River plant may be approximately equal to the volume of oil produced. Information regarding the plant output in 1932 and 1933 was not obtainable. In August, 1935, this generating plant was moved at a cost of $10.00 per kw. of capacity to a site 12 miles distant to serve a different group of wells. It should be mentioned that the oil company operating this

(Continued on Page 95)

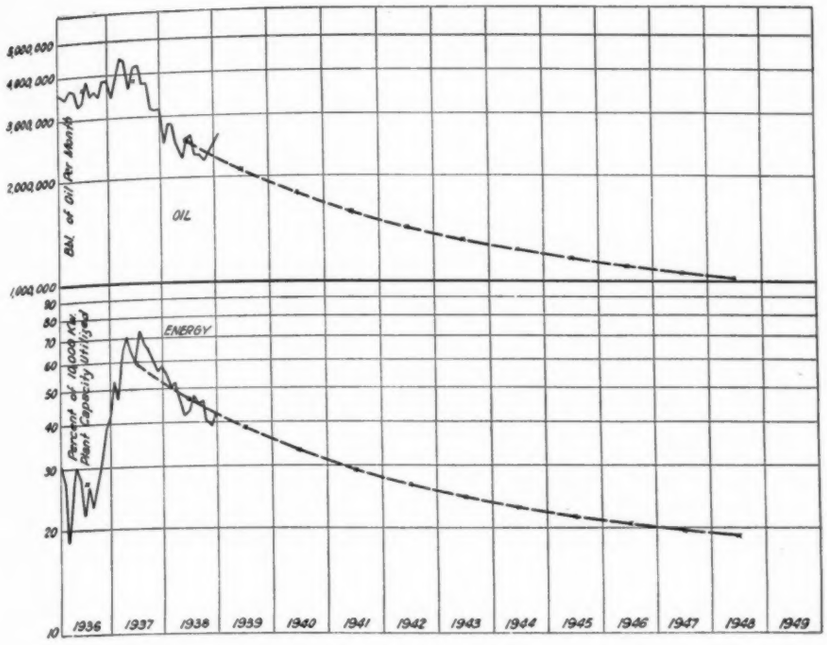


Fig. E. Upper part of chart shows volume of oil in bbl. produced from the Wilcox zone in Oklahoma City field during 1936, 1937, and 1938. The extension of this curve indicates the expected normal decline of production. In the lower part of the chart is shown power purchased by one large company during 1936, 1937, and 1938, and estimated requirements through 1949

(Continued from Page 92)

plant produces oil in a number of other nearby fields in which electric power could be used. Smaller oil companies ordinarily would not have very extensive operations and would be forced either to let the equipment no longer needed remain idle or to sell it.

In Fig. D the volume of oil (in bbl.) produced by an oil company in the Fitts pool is shown by months during 1936, 1937, and 1938. On the lower portion of the chart are shown the monthly percentages of the total capacity used. A generating plant of 2500-kw. capacity was installed in December, 1936, and wells were added thereafter to the load until January, 1938, when a total of 205 motor-driven beam pumps were being supplied with power. In 1938 this number of wells produced in total an average of 426,000 bbl. of oil per month compared with an average of 644,000 bbl. per month in 1937. It is estimated by reliable authority that about 125,000 bbl. of water is being produced each month and indications are that this water production will remain more or less constant in volume for a considerable period of time.

Normal decline curves for this company's leases in the Fitts field have been extended in Fig. D to and including 1947. Note that the total production declines from 545,000 bbl. per month in 1938 to 185,000 bbl. per month in 1947, or a decline of 66 percent. Accordingly, the electrical energy required to pump the wells may be expected to decline proportionately except for a slight correction factor to take care of the increase in specific gravity of the liquid produced from .92 in 1938 to an estimated 1.06 in 1947 as the percent of water increases.

In the upper portion of Fig. E the volume of oil (in bbl.) produced from the Wilcox zone in the Oklahoma City field is shown by months for 1936, 1937, and 1938. One of the large oil-producing companies contemplated installing a 10,000-kw. steam-driven generating plant in 1935. After a careful study of the possibility of having to discontinue rapidly the use of certain types of lifting equipment, the idea of generating electric power was abandoned as being uneconomic. Power purchases of this company beginning in 1936 are shown in the lower portion of Fig. E as monthly averages in terms of "percent of maximum capacity" based on the capacity of the 10,000 -kw. plant originally proposed. The rate of normal expected decline of production from the Wilcox zone over the entire field was applied to the upper production curve. Extrapolating the values for ten years from January, 1939, the total recovery from the Wilcox zone is indicated to be nearly 470,000,000 bbl. This estimate appears reasonable, when it is considered that the total recovery to January, 1939, from the Wilcox in the Oklahoma City field had been 317,000,000 bbl. of oil.

It is estimated that the Wilcox zone wells will produce not much more than five to ten percent of water.

In further discussion of Fig. E note that the decline in the estimated amount of purchased electrical energy parallels closely the estimated decline in oil production. Thus, the average monthly production from the Wilcox zone in the entire field falls off from a monthly average of 3,800,000 bbl. in 1937 to 1,050,000 bbl. in ten years, or a drop of 72 percent. Similarly, the generating plant "percent maximum capacity" is assumed to fall from its peak of 73 in 1937 to a value of 20 ten years later, or a loss of 53 percent.

Of course, if repressuring or water-flooding is applied in 1941, as is contemplated in studies being made at the present time, a new generating-plant load curve would be necessary, and a new oil-reduction curve would be superimposed on the present decline curve, which would show an additional recovery from the Wilcox zone of about 200,000,000 bbl. For the purpose of this discussion, however, the possibility of water-flooding will be disregarded.

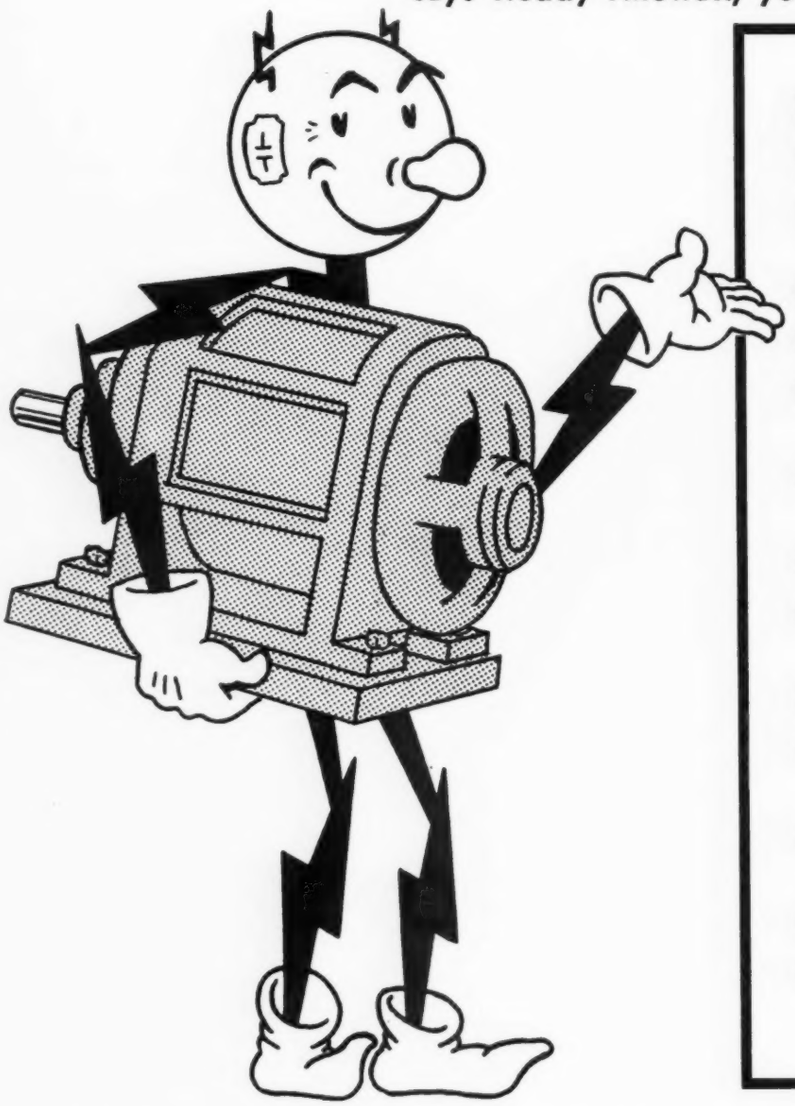
So far in this paper studies have been presented of both actual and probable

(Continued on Page 98)

In RODESSA there is no PURCHASED

"These Advantages of Mine Increase Profits"

— says Reddy Kilowatt, your electric servant



WHY PURCHASED ELECTRIC POWER SERVICE ASSURES LOWER PUMPING COSTS

- Lower first cost.
- Lower maintenance cost.
- Lower fixed charges (taxes insurance, depreciation, etc.)
- Less trouble, fewer repairs, smoother operation.
- Longer life for all equipment.
- Fewer accidents and less fire hazard.
- Easy to start in any weather.
- Operation can be controlled automatically.
- High salvage value in electric equipment—easily moved.
- Clean and efficient.
- Accurate records more easily kept.

SOUTHWESTERN GAS

Oil Field Offices: Gladewater, Longview, Henderson, Kilgore

and EAST TEXAS economical substitute for ELECTRIC POWER

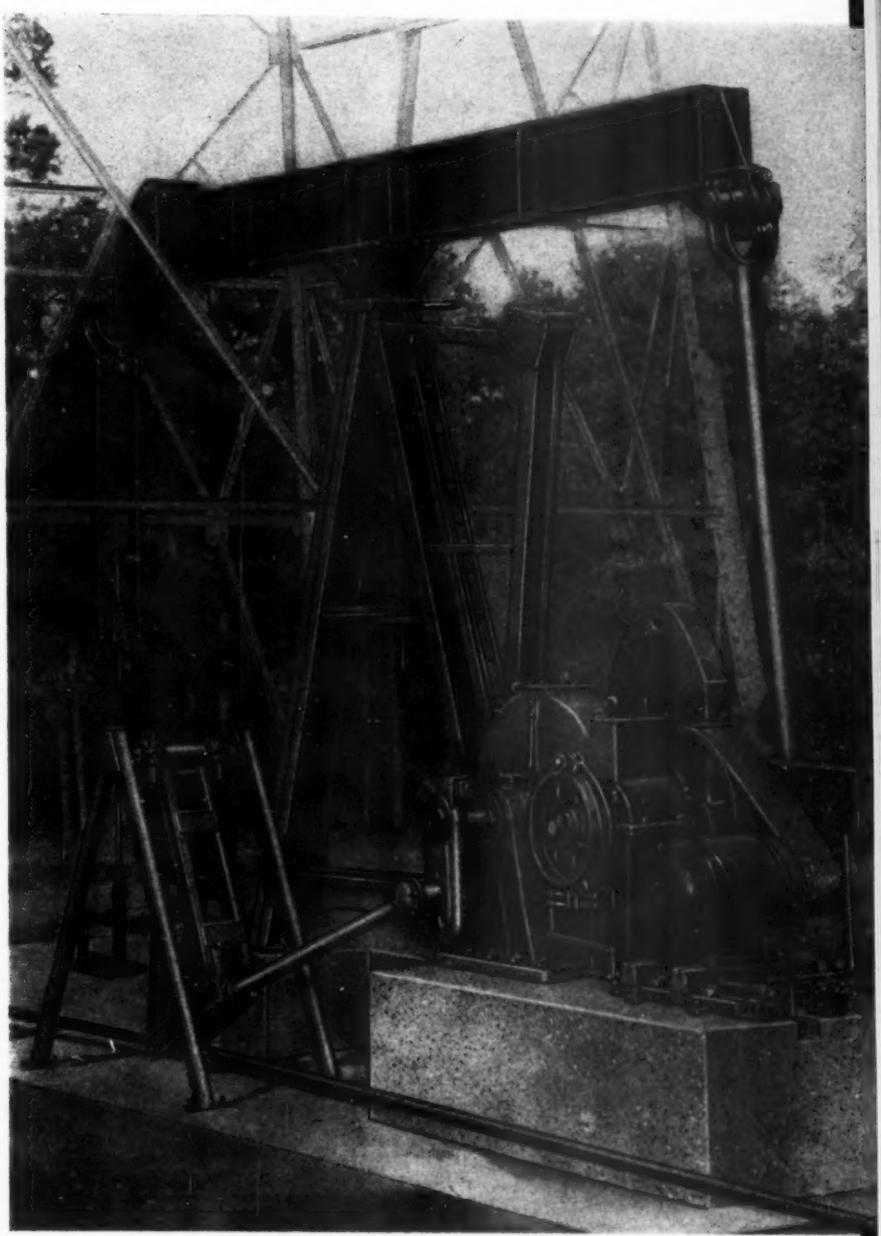
Companies using PURCHASED ELECTRIC POWER for *drilling—production—pipe line pumping*—and *refining*—are enjoying increased profits every day. PURCHASED ELECTRIC POWER will do your job more efficiently for less money because it is the modern power adapted to modern oil field operations.

The electric motor is particularly adapted for oil well pumping because it is . . . flexible . . . dependable . . . compact . . . and results in a low overall cost per barrel of oil pumped.

PURCHASED ELECTRIC POWER makes it easy to secure additional power for temporary or permanent use on short notice. You can increase or decrease your power requirements at a minimum expense.

PURCHASED ELECTRIC POWER is always used by operators interested in increased profits. IT MAY SAVE *YOU* THOUSANDS OF DOLLARS!

If you have a power problem in the East Texas or Rodessa fields, communicate with our Industrial Engineering Department. One of our engineers will be glad to furnish you with information on what other successful operators are accomplishing with PURCHASED ELECTRIC POWER without cost or obligation to you.



& ELECTRIC COMPANY

General Offices: SHREVEPORT, LOUISIANA

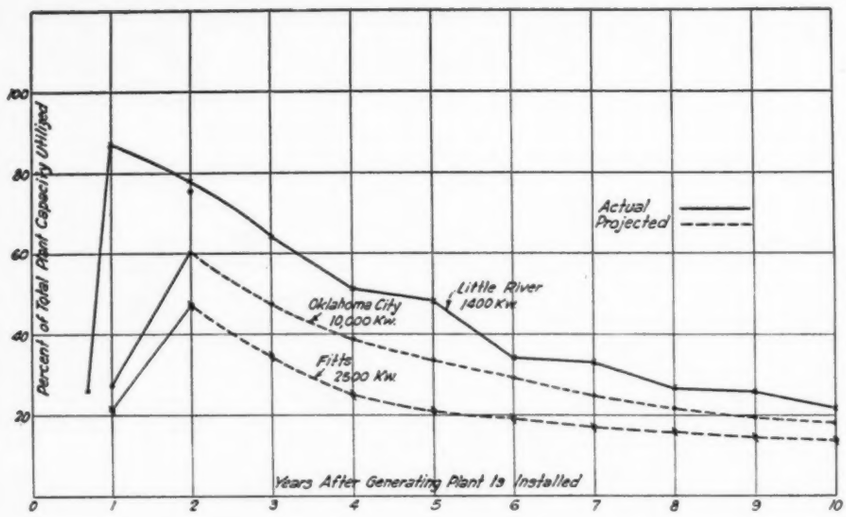


Fig. F. In this curve Figs. C, D, and E are replotted to show more clearly the use made of plant capacity as affected by the inherent power requirements of the given oil field during the period studied

(Continued from Page 95)

output of generating plants under conditions of actual and probable pumping requirements over a long period. The factual information obtained from these studies (Figs. A, C, D, and E), which cover a wide variety of circumstances in different oil fields, has a certain value. Of greatest significance, however, is the fact that after about ten years those generating plants serving specific oil fields are required to operate only 15 percent to 20 percent of their original installed capacity.

In order to obtain a better perspective of the cases studied herein, the curves from Figs. C, D, and E are replotted on a single sheet of regular cross-sectional paper as in Fig. F to show more clearly the use made of plant capacity as affected by the inherent power requirements of the given oil field during the period of time studied.

A study of Fig. F reveals that in all three cases studied only about one-fourth of the total capacity is required during the first year.

The Little River Plant, after its first three months' operation in 1928, operated at 87 percent capacity during the first year. Plant capacity use then dropped gradually to 22 percent in 1938 after ten years.

The slopes of the three curves in Fig. F are generally parallel throughout the period, lending merit to the conclusion that generating plants, the purpose of which is to provide power for pumping wells, regardless of location, are destined to reach the same low rate of utilized capacity after a few years.

The 1400-kw. generating plant installed in the Little River field comprised four 500-hp. gas engines, each driving a 350-kw. generator. This plant cost $200,000 and high-line construction added another $20,000 to make a total investment of $220,000.

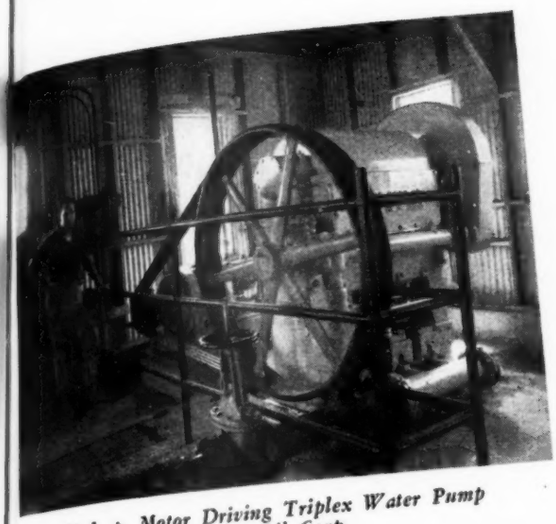
To provide for fixed charges consisting of seven percent annual depreciation (compounded) based on a 10-year life, five percent interest, and two percent for taxes and insurance, a total of $30,800 should be allocated out of earnings each year. Operating labor of $250 per week, or about $12,000 per year should be added to provide for two operators per shift (on a 40-hr. per week basis). No charge need be made for maintenance during the first year, but beginning in the second year this item should be increased gradually to $7.00 per hp. in the tenth year, based on actual records. Lubricant cost is also an item of generation expense. A charge of 20 cents per 1000 kw-hr. generated is a fair figure to use for lubricant cost. The fuel used is considered as having no value. Thus, the Little River Plant, operated at 87 percent utilization of installed capacity as it was during 1929, the first full year of operation, generated 10,650,000 kw-hr. at a cost of approximately $43,000. During the tenth year, 1938, the plant generated only 2,700,000 kw-hr., 22 percent of the original installed capacity. The fixed charges in the tenth year are reduced to $23,500 because of the reduction in plant-investment to $160,000 through the sale of two 500-hp. engines, two generators, and a switchboard, at $40 per hp. Labor is not reduced appreciably, however, so the total operating cost in 1938 probably was close to $36,000.

Thus, generating costs during 1929 averaged only 0.4 cent per kw-hr. but in 1938 the cost mounts to 1.4 cents per kw-hr. or an average of somewhere between 0.8 and 0.9 cents per kw-hr. for the ten-year period studied.

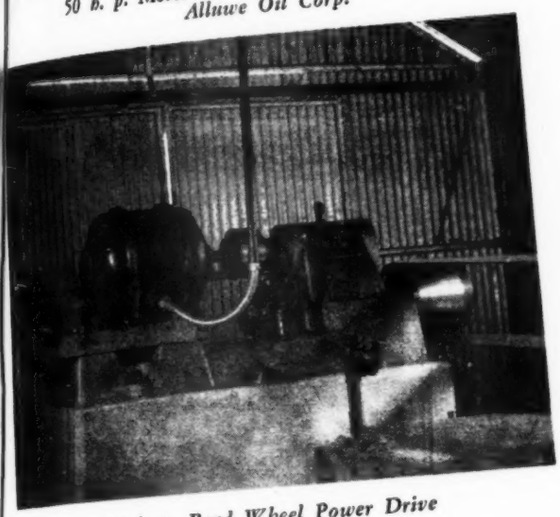
In a great many instances engineers take the position that if depreciation is neglected, and the difference between the out-of-pocket operating cost and the cost of purchased power is considered as a saving, the plant could be paid out in four or five years.

This may be true in some cases; however, in Fig. F note that the inherent energy requirements of the Little River field average only 28 percent of the original installed capacity during the last five years. At this low rate of use the cost of operating the generating plant would be far greater than the cost of purchased power in the amount needed. Such excessive operating costs would overcome the apparent savings of the first five years. The resultant cost of generating power over the ten-year period studied may, therefore, become equal to or slightly greater than the total cost of purchased power during the entire period.

WATER FLOODING OPERATORS
Increase Use of
PURCHASED ELECTRIC POWER
In Northeastern Oklahoma

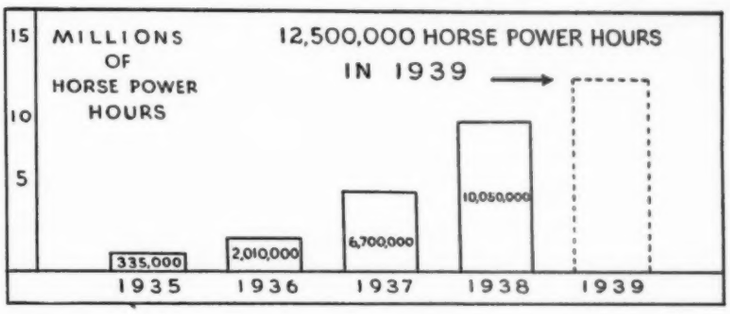


50 h. p. Motor Driving Triplex Water Pump
Alluwe Oil Corp.



30 h. p. Band Wheel Power Drive
H. J. Walters Company

5-75 h. p. Centrifugal Pressure Pumps at No. 1 plant of Forest Producing Corp.

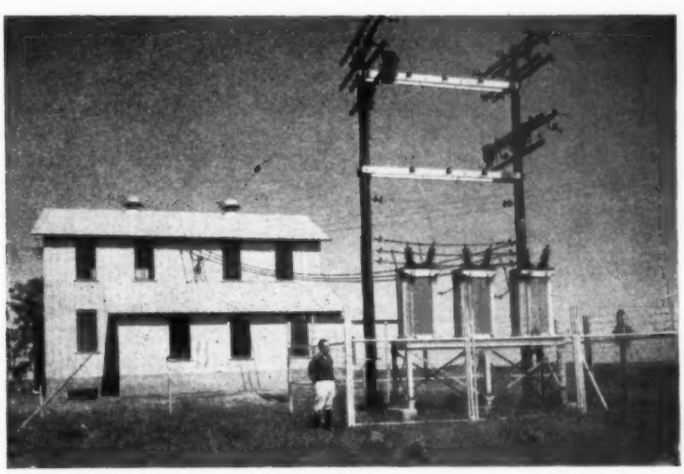


Operators agree that one of the most important factors in the recovery of oil by the water flooding method is a dependable and flexible power supply that adapts itself to the major plan of development.

The Public Service Company of Oklahoma has helped operators get continuous operation and increased production by making available a reliable supply of electric power to fit the customers' specific needs. Through purchased electric service, producers have been able to reduce initial development costs with the direct application of motors to pumping equipment, in small increments as needed. They have been saved all worry as to unpredictable future trends, for added requirements—large or small—can be provided quickly and easily.

In addition, labor requirements and maintenance costs have been reduced because all the problems of power supply are handled by trained employees of the utility company whose only duty is to provide a continuous and reliable low cost power service.

The Public Service Company of Oklahoma also has experienced power engineers to lend assistance on power applications without charge to operators in the field.

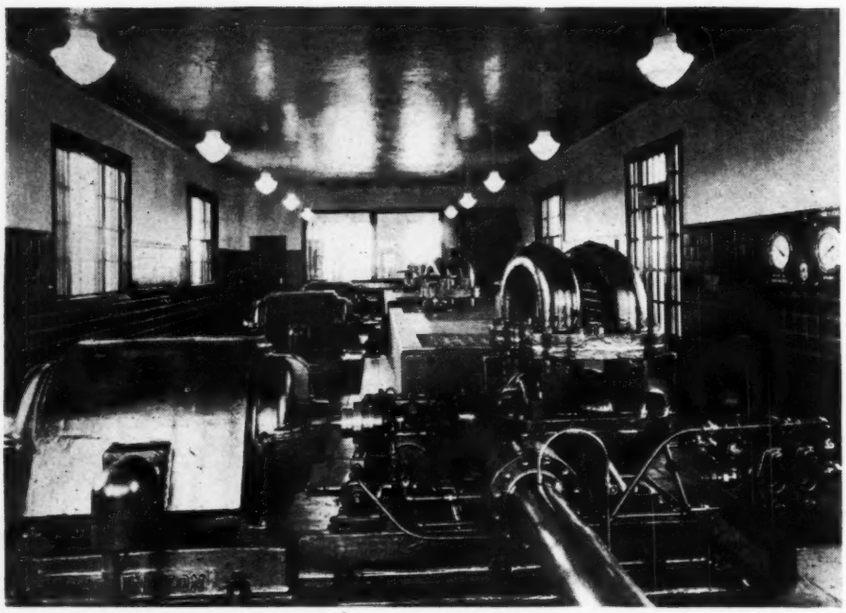


No. 4 Pumping Plant, Forest Producing Corp.

PUBLIC SERVICE COMPANY OF OKLAHOMA
TULSA, OKLAHOMA

Consult Our Engineers on Power Problems

P 516.9
P 615.511
P 762.2



Oil pipe-line pump station using three 400-hp., 3600-r.p.m., motor-driven pumps, and one standby

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

By G. R. PROUT,
General Electric Company

Recent Developments in Electrical Equipment in the Petroleum Industry

Improvements include better-housed motors for out-of-doors service and for safer operation in hazardous atmosphere—new supervisory relay system insures continuous service during a fault in one of the feeders

ELECTRICITY, for many years, has played an important part in every phase of operation in the petroleum industry. Exploration, drilling, well-pumping, pipe-line and tanker transportation, refining, and marketing divisions have all used electric service and equipment to an important extent in operations.

It is not the purpose of this article to cover the entire field of application of electrical apparatus and service to every phase of the petroleum industry but rather to cover some of the advantages afforded and the economies made possible by the use of electricity in well-pumping, pipe-line pumping, and refinery work.

Well-Pumping

The problems involved in lifting oil to the surface vary with producing areas and even vary between individual wells in a single field. There is no one answer to all problems nor is there a single method of operation or a single type of equipment that serves every requirement best.

Power companies serve many of the producing areas in all oil-producing states with economical, reliable service that is difficult to equal using any other form of energy.

Electric motors are widely used for well-pumping and prove many advantages.

The first cost of present-day motor installations is low. Splashproof squirrel-cage motors are being used widely. These motors are installed out-of-doors without housings and provide a convenient form of power. Weatherproof control is also widely used and is simple and inexpensive.

The squirrel-cage motor is not a complicated machine mechanically; its maintenance cost, therefore, is extremely low. It provides reliable operation over a long period of time with a minimum of attendance. It is easily started in cold weather and provides a convenience in operation equalled by no other form of power.

Automatic operation by time-switches is frequently employed to reduce operating costs. When time-switches are used, they are mounted in the weatherproof control units and interwired so that a pumper may start the well manually and then easily set the time-switch to shut-down at any

G. R. PROUT

has both a bachelor's and a master's degree in electrical engineering from the Massachusetts Institute of Technology, the latter received in 1923 — He worked a year for the General Electric Company in its New England District and was then transferred to the Southwest, where he has been since—From 1927 until the present his chief interest has been in the application of electrical equipment to the petroleum industry, with particular respect to oil-well drilling, well-pumping, pipe-line pumping, and refinery operation—He is acting district manager of the Industrial Department, Southwestern District, of the General Electric Company—His home is in Dallas, Texas.

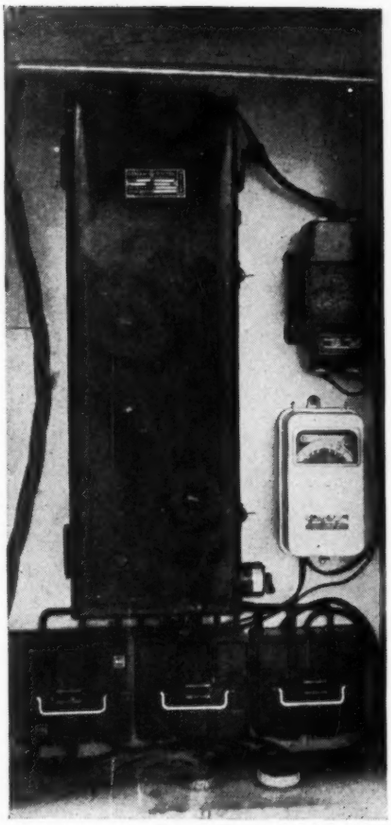
later time. If conditions permit, he can set the switch to start each well automatically at a predetermined time and also shut it down automatically at a later time.

The reliability, ease, and convenience of operation and the automatic control features afforded by electric motor operation in well-pumping permit a minimum cost for attendance. This advantage is particularly valuable to any industry operating under present-day conditions, when every possible economy must be effected in order to produce at even a nominal profit.

Electric motors provide a smooth continuous motion of equipment throughout the entire pumping cycle resulting in a reduction in maintenance of mechanical equipment and rods.

In producing areas where 24-hr. pumping is required, continuity of service is vital. This is especially true in areas where water-encroachment is serious. A well shut down for a relatively short time under such conditions may require a long period of continuous non-productive pumping to bring it back to its former oil-producing capacity. Electric motors, served by utility companies from dependable power lines and plants, provide operation with a minimum of down time and offer advantages in areas where continuous operation is important.

There are several types of squirrel-cage motors suitable for oil-well pumping. These various types of motors differ from each other in starting torque, starting current, efficiencies, speed regulation, and maximum running torque. Consequently, one type may possess advantages in one application and another type may possess advantages under other conditions.[1]



Interior view of a weatherproof control unit for an oil-well pumping motor

All these types of motors are similar mechanically. All are being supplied in splashproof construction for outdoor use with either ball-bearings or sleeve-bearings. These motors are also being supplied in the totally enclosed, fan-cooled type of construction for outdoor use.

The control equipment used with these motors is the same for one type as for another. This control in its simplest form consists of a fused entrance or disconnecting switch, a magnetic contactor, a thermal overload relay, and a "start-stop" master switch. These devices are usually mounted in a weatherproof sheet-steel housing. In some cases a separate, weatherproof, "start-stop" push-button station is installed at the pumping unit.

When automatic time-switch operation is desired, a suitable time-switch is mounted in the same weatherproof housing and a "manual-off-automatic" master switch is substituted for the "start-stop" master switch or push-button station mentioned.

When it is desired, a small, air-cooled, lighting transformer may be supplied in the same housing to provide 110 volts for rig lighting.

It is also common practice to install a small lightning protective device, with or without a suitable capacitor, to protect the motor and the control against damage from lightning.

Oil Pipe-Line Pumping

Electric motors have been widely used to drive pumps in oil pipe-line pumping service. A total of approximately 200,000 hp. in electric motors has been installed in oil pipe-line pump stations.

In this application, continuity of operation is essential. As operation 24 hours a day is required, the utmost in reliability is a necessity.

In many areas, power companies are giving service that permits this kind of operation. There are many electric pumping stations that have been in continuous, 24-hr. a day, service for several years. These stations have pumped oil very economically.

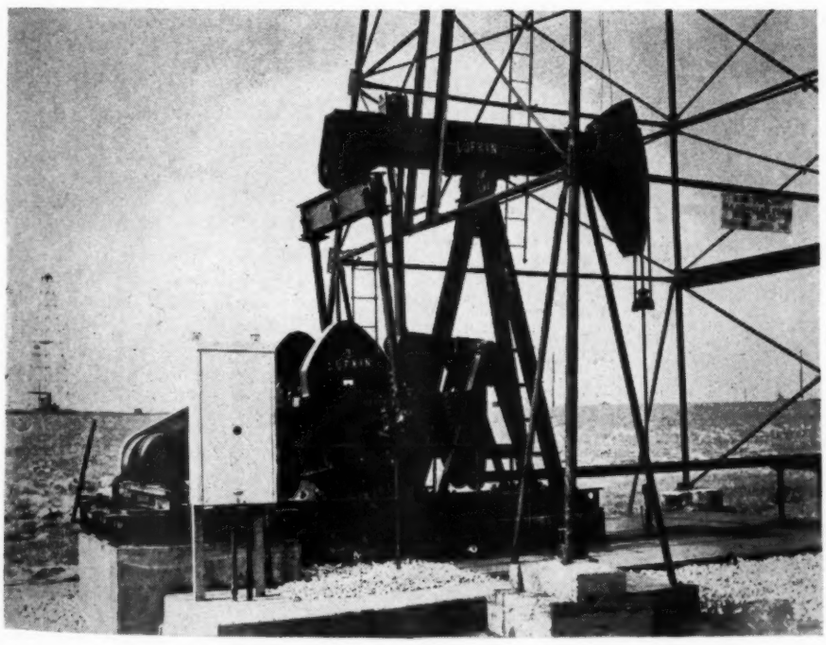
The squirrel-cage motor has been used most frequently in pipe-line service; nevertheless, synchronous motors are being used where operation at unity power factor offers an advantage.

Most of the motors used in pipe-line service are driving centrifugal pumps, although there are some driving reciprocating pumps.

The most efficient centrifugal pumps for pipe-line service operate at approximately 3600 r.p.m. The use of 3600-

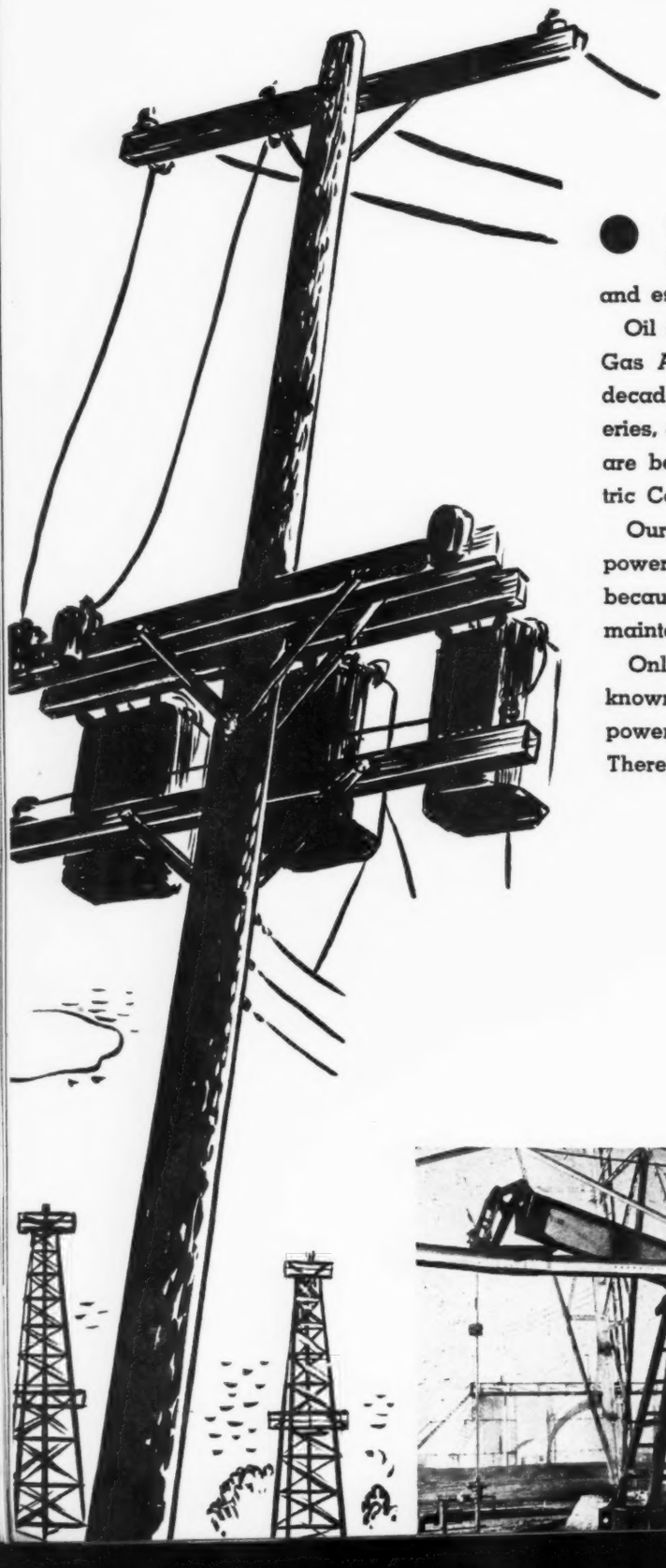
(Continued on Page 104)

[1] "Progress in the Application of Electric Motors for Oil Well Pumping", *The Petroleum Engineer*, Midyear, 1938.



A modern installation of a 10-hp. splashproof motor and weatherproof control on a reduction-gear pumping unit on a well in Kansas

In Oklahoma.



Electric power is a big boon to the petroleum industry. In fact, it has virtually revolutionized production methods and established new standards of efficiency and economy.

Oil operators, realizing its benefits, have utilized Oklahoma Gas And Electric Company's service many years ago—two decades to be exact. Today, Oklahoma's world famous refineries, giant pipeline stations, and thousands of wells on pumps are being operated electrically by Oklahoma Gas And Electric Company's extensive power facilities.

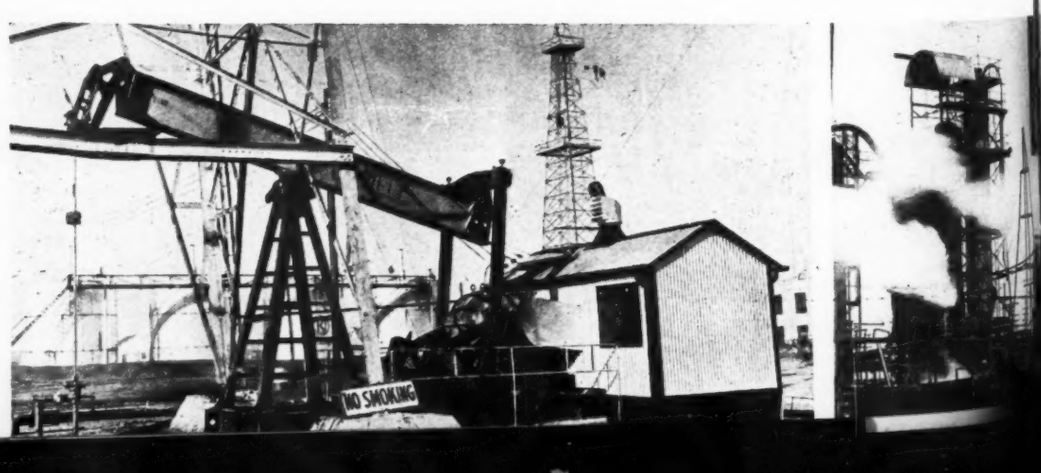
Our rates are adjusted to meet your needs for an economical power. In addition to this advantage the over-all cost is lower because electrically powered equipment costs less to install, maintain and operate than most other types of power equipment.

Only through a complete presentation of facts can we make known all the outstanding advantages of this truly modern power. So why not let us give you the entire story — now! There's no obligation on your part, of course.

PROFIT BY USING Purchased ELECTRIC POWER

At left, below, view of one of thousands of wells electrically operated by power furnished by OG&E.

At right, below, scene of refinery using Purchased Electric Power — one of of many serviced by OG&E.



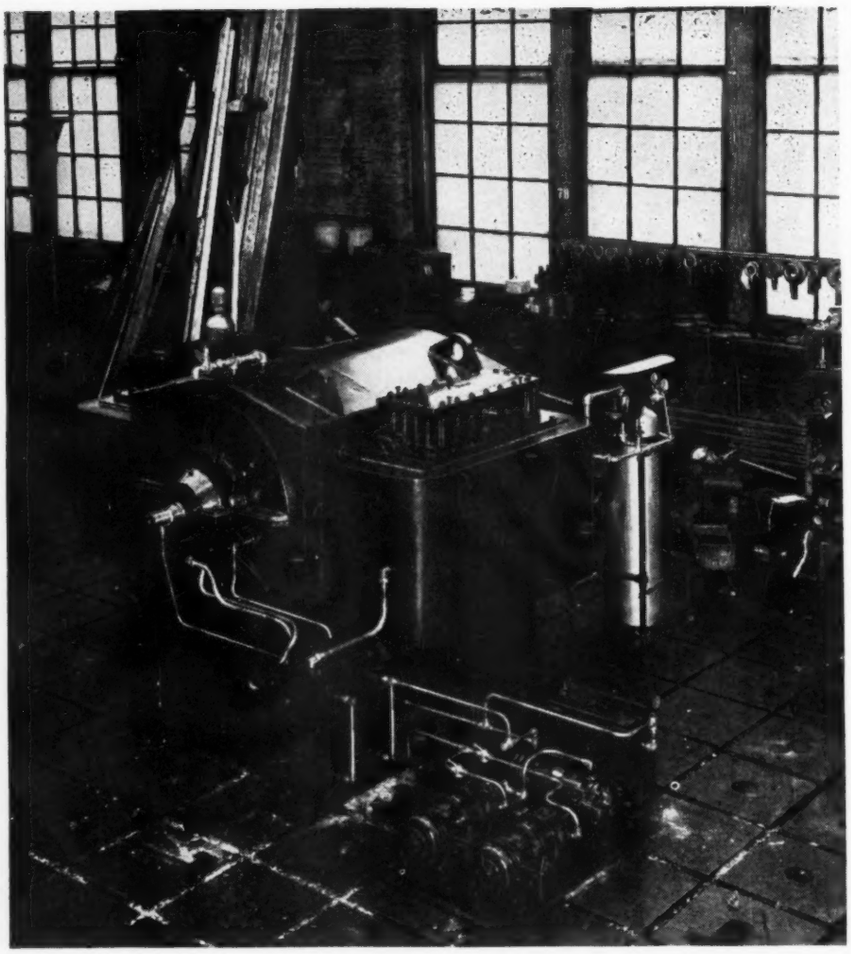
THE O.G.&E. SERVES THOUSANDS OF OPERATORS WITH PURCHASED ELECTRIC POWER!

The above map illustrates the extensive power facilities of OG&E which service almost every active field in Oklahoma. For further information concerning our service and advantages of electric power, visit your nearest OG&E branch office, or Mr. W. H. Stueve, in the general office, in Oklahoma City.

OKLAHOMA GAS AND ELECTRIC COMPANY

Commercial Department

OKLAHOMA CITY — W. H. STUEVE — OKLAHOMA



A 1000-hp., inert-gas-filled, totally-enclosed, squirrel-cage motor, arranged with surface coolers. This installation is in a Pacific Coast refinery

(Continued from Page 101)

r.p.m. motors direct-coupled to the pumps eliminates the need for a speed-increaser between the driver and the pump as is required when slow-speed drives are used.

The motor-driven centrifugal pump for oil pipe-line service is relatively inexpensive. It is light-weight, occupies relatively little space, and is therefore easily transported and installed. The foundation required for such a unit is also small and inexpensive. The motor-driven pump unit to handle 42,000 bbl. per day at a pressure of 400 lb. per sq. in. (two such units required per station), has a weight of approximately 9000 lb. including the bed-plate. Over-all dimensions of the unit, including a 350-hp., 3600-r.p.m., 2200-volt, squirrel-cage motor, are approximately ten ft. long by four ft. wide by five ft. high.

The first cost of a pumping station using two motor-driven pumps as described is very low. The simplicity of such a station is most desirable from an operating standpoint.

In the operation of a pipe-line station of any type, everything goes smoothly the greater part of the time. When a station is started up, however, it is necessary for the pumper to operate valves and to watch pressure gauges, pump-bearings, pump-packings, etc. When anything goes wrong anywhere in the entire pipe-line system, it is necessary for a pumper to "stand-by" at the pumps in each station.

In a motor-driven pump station, the operator can devote his time to pump operation because the motors require little attention. He can stop the motors by means of push-button stations situated near the pumps. If full magnetic control is used, the operator can also start the motors by push buttons.

In a station not using electric motors with purchased power, good operation requires an operator on duty at the prime movers as well as at the pumps. This necessitates a minimum of two operators per shift. Some few stations that do not use electric motors and purchased power are being operated by one operator per shift but there is always a second operator on call 24 hours a day.

In stations using only one operator per shift with a second on call, the operator's entire time is taken up with the routine of operation. He has little or no time to do ordinary station maintenance work, much less to care for grounds, etc.

The importance of continuity of operation, the necessity for two operators under certain conditions of operation, and the requirements for maintenance of station and grounds almost dictates that two operators be on duty per tour in a pump station if electric motors and central station power are not used to drive the pumps.

Many major companies have operated motor-driven centrifugal pump stations using purchased power for years with only one operator per shift. This experience has proved that one operator per shift in a motor-driven station is sufficient under all conditions of operation and also provides time for routine maintenance of equipment, station, and grounds.

The above indicates that minimum attendance cost can be attained by using motor-driven centrifugal pumps and purchased power.

The first cost of the complete station using electric-motor-driven centrifugal pumps will be approximately 23 percent of the first cost of a station using centrifugal pumps not driven by electric motors and purchased power. The percentage will vary somewhat depending on the type of construction used, the number of operators' cottages, and other factors; however, the figure used does not include any spare capacity in either type of station. If spare equipment is included, the percentage will further favor the motor-driven pump station.

The low first cost of the motor-driven station provides several advantages. One of these is the lower annual charges for taxes, insurance, and depreciation.

The low first cost is also important when the hazard of investment is considered. Certainly a pipe line costing many millions of dollars would not be installed unless it were reasonably certain that the line would run somewhere near full capacity for many years. Nevertheless, some lines have been constructed and have operated at full capacity for no longer than 18 months when it seemed certain, in the beginning, that the line would run at full capacity for at least ten, and possibly 20 years. This is no reflection on those who made decisions on projects of this kind but merely indicates the hazard that accompanies an effort to forecast the future.

Unsettled conditions throughout the

IN SOUTH AND SOUTHWEST TEXAS

Purchased Electric

REDDY KILOWATT
WILL NEVER
LET YOU DOWN

POWER

IS READY TO WORK FOR YOU

10 REASONS Why Purchased Electric Power IS BEST:

- Low first cost, and lower maintenance cost.
- Low fixed charges (taxes, interest, etc.)
- Less trouble and fewer repairs.
- Longer life, and higher salvage value.
- Fire hazard at lowest possible point.
- No water supply to worry about.
- Few accidents—less insurance to pay for.
- Power costs are easily figured—records easily kept.
- Small warehouse stock of repair parts.
- Less shut-down time.

Oil men engaged in producing, pipe-lining or refining "black gold" from South and Southwest Texas oil fields are relying more and more upon the DEPENDABILITY, ECONOMY and HIGH EFFICIENCY of purchased electric power.

C. P. and L.'s electric transmission lines criss-cross the Soutex oil empire like a spider's web, making immediately available to every field (and there are 153 of them within three hours ride of Corpus Christi) a ready and unlimited supply of electrical energy for any purpose.

Electric power costs less today than ever before. And that is just the beginning point of economy. When wells are shut-in, or other operations cease, YOUR power costs stop, too. You pay for only what you use when Reddy Kilowatt is your servant.

Our power engineers, experts in all oil industry power problems, are available for consultation at your convenience. See the office nearest you, or write our Commercial Department at Corpus Christi.

★CENTRAL POWER AND LIGHT COMPANY

SERVING 180 COMMUNITIES IN SOUTH AND SOUTHWEST TEXAS

world today make it more difficult than ever to attempt a prediction of the future.

Under these circumstances, it would seem most desirable to keep initial investment low. This is especially true, if desirable, economical operation can be obtained by the use of the less expensive type of station.

The maintenance cost and the time required to maintain electric motors will not differ over a long period of time from that of other equipment. The cost to rewind completely a 350-hp., 3600-r.p.m., 2200-volt, squirrel-cage motor such as is commonly used in pipe-line service is approximately $550.00. The cost to rebabbit and machine a bearing for such a motor is approximately $35.00. When it is considered that motors in pipe-line service seldom burn out and that these motors have only two bearings, it is evident that maintenance costs are low.

The control equipment used with these motors also requires but little maintenance and this at low cost.

An electric motor can carry a load equivalent to its rating 24 hours a day for an almost indefinite period without serious injury to the insulating materials used in the motor. Bearings are the only mechanical parts that may wear, but well-designed, well-lubricated motor bearings of the type available today should operate without excessive wear or trouble for many years.

Electric motors and controls as used in pipe-line pump stations do not require maintenance crews to work continuously on equipment in the various pump stations on a line. Usually one electrical maintenance man can maintain the equipment in a number of stations, and even this will not usually require his full time.

Electric motors afford reliable, economical, convenient operation in pipe-line service and this fact is attested by the large number of pump stations using electric service for driving oil pipe-line pumps.

Refineries

Refining methods and practices have changed rapidly during the last few years. These new developments have required much new construction of refining units and large amounts of capital have been invested.

There has been a marked increase in the use of electric motors in these new units. The increased use of motors is due to several factors, some of which are: (1) the requirement for process steam has decreased, (2) lower maintenance and operating costs are essential, (3) centrifugal pumps for refinery service have been further developed, (4) motors and controls especially applicable to refinery service have been perfected, and (5) electric drive provides convenient, safe, reliable operation.

A great many refineries are at least 50 percent electrified and there are some that operate 100 percent electrically. Some of these plants are purchasing electrical energy from power companies.

A refinery, too, must have the utmost in reliability in power and equipment. Operation 24 hours per day for a continuous period of 60 days is not uncommon, and then after a few days shutdown, the cycle is repeated. One plant of medium capacity ran 108 days continuously without a shutdown, and there may be others that have equaled or exceeded this performance.

Many refineries have their own generating plants. Many of these are large refineries and require an appreciable amount of process steam, which makes possible very low generating costs using steam-turbine generator units. Some smaller plants are using gas-engine generators that provide low power costs in refinery service when the fuel costs are extremely low.

Some of the refineries that generate electricity have interconnections with power companies for standby service. There are also some refineries that purchase 100 percent of their power from utility companies.

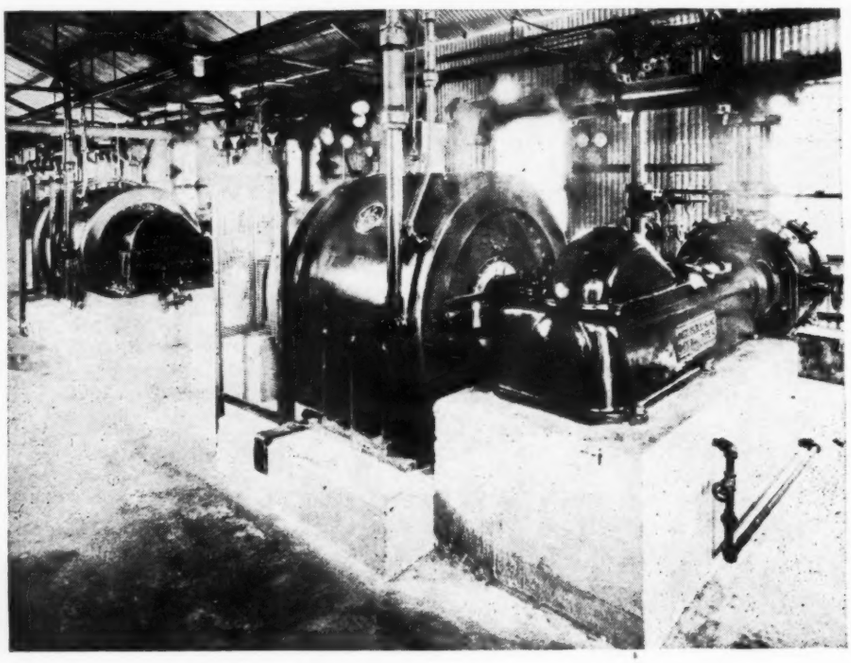
Obviously, when purchased power is used, special consideration must be given to assure continuity of service. Usually this is accomplished by two-way feed to the refinery from a reliable power system.

In some cases, an automatic throw-over arrangement is used to connect the refinery distribution system to the auxiliary feeder in case the preferred feeder goes out of service for any reason.

In recent years, however, a new supervisory relaying system has been developed that permits both feeders to the refinery to be energized at all times. This equipment is so designed and connected that if one feeder, or any section of it, gets into trouble, the relays operate in such a way that all automatic oil circuit-breakers in the system that would normally trip open on such a fault are closed automatically, except those that must open to remove the faulted section from the system. The faulted section is removed from the system automatically and the refinery has no interruption of service. Signals are given automatically indicating that the faulted section has been removed from service. This section can then be repaired and returned to service without interrupting service to the refinery.

The plant of the Atlantic Refining Company at Port Arthur, Texas, is the first refinery to use purchased electric energy through such a system. This plant depends entirely upon purchased power for its operation and no serious shutdowns have occurred because of power failures.

Totally enclosed, fan-cooled motors,



Two enclosed, fan-cooled, synchronous motors, 100-hp., unity power factor, 277 r.p.m., each with non-combustible-gas-filled interior and each coupled to a reciprocating compressor. This installation is in a gas-gathering plant of a Texas refinery

● Close to the industrial, geographical and population centers of the Nation lies the broad diversified territory served by the Public Service Company of Northern Illinois.

Here can be found all the factors favorable to the continued growth and expansion of the petroleum industry. Great markets and unrivaled transportation facilities . . . favorable tax rates . . . unlimited choice industrial sites . . . a wealth of skilled and unskilled labor . . . and a constant supply of dependable, economical, flexible purchased electric power.

Out from the central generating stations go the "life-lines of industry"—power lines reaching every type and size of business. Over these lines go the electric supply on which industry depends for adequate and reliable power to insure production and employment.

Why not investigate the possibilities of locating your operations in this thriving Northern Illinois area? Complete information may be obtained from the Industrial Department of this company.

The area served by the Public Service Company of Northern Illinois includes 6,000 square miles and extends distances varying from 30 to 150 miles north, west and south of Chicago.

PUBLIC SERVICE COMPANY
OF NORTHERN ILLINOIS

GENERAL OFFICES: 72 West Adams Street, Chicago

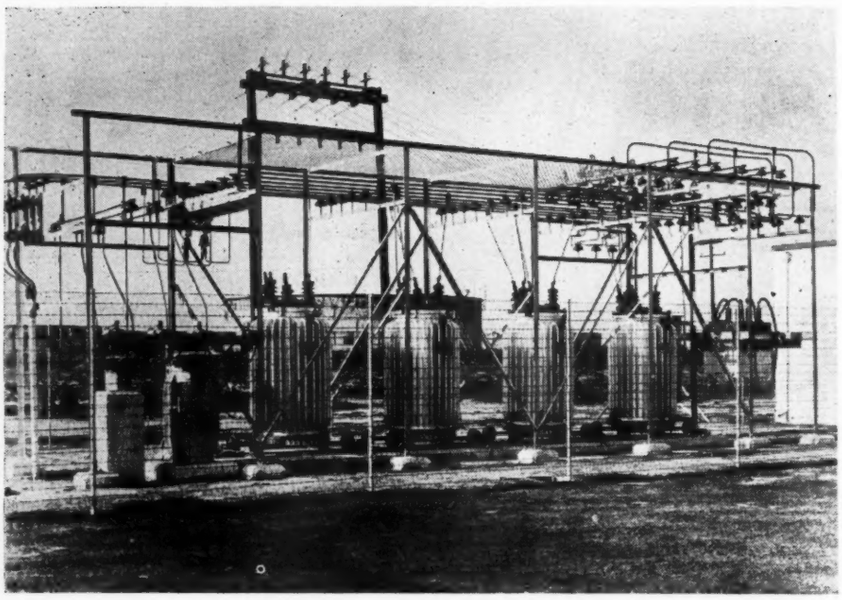
PURCHASED ELECTRIC SERVICE OFFERS THESE ADVANTAGES TO THE PETROLEUM INDUSTRY

Dependability—Assures continuous operation; helps increase production; contributes to economical operation of equipment.

Flexibility—Makes expansion problem easier; saves carrying charges at the time of low production; meets rapidly changing power needs; makes possible double shifts and night work without special arrangements for power and light service.

Constant Frequency and Voltage—Maintains constant speed; maintains production schedules; insures operation of lights at proper brightness; allows temporary over-loading of equipment.

Low Investment—Saves capital expenditure; enables employment of capital to best advantage in the business; reduces loss in fixed charges during idle time; reduces economic risk; avoids losses in power plant obsolescence; permits forecast of power costs.



Sub-station for an oil pipe-line pumping station using electric-motor-driven centrifugal pumps and purchased power

enclosed base-ventilated motors, and inert-gas-filled motors have all been developed in recent years primarily for refinery service. All these motors provide convenient, economical operation with a degree of safety much greater than has been obtained in the past.

The selection of type from the abovementioned list depends upon the rating of the motor involved. The totally enclosed, fan-cooled "explosionproof" motor is now available in all sizes to approximately 400 hp. at 1800 r.p.m. and 3600 r.p.m. Above these ratings, the base-ventilated motor or the inert-gas-filled motor may be used.

The totally enclosed, fan-cooled motor is being used extensively out-of-doors without shelter in many refineries. This permits a saving in installation cost. The insulation in the motor is protected from rain or moisture in the atmosphere. It is also protected from the corrosive gases found in refineries and from dirt and dust.

Adjustable-speed motors are frequently required on pumps in refineries. Unfortunately, the induction motor is essentially a constant-speed machine. It is possible to obtain speed reduction under load conditions with a slip-ring induction motor by placing resistance in the rotor circuit. When this is done, however, the efficiency is reduced, and if the load is a constant-torque load the input to the motor will be approximately constant regardless of the speed at which the motor is made to operate by putting resistance in the rotor circuit.

Obviously, if a motor is to operate for long periods of time at reduced speed, efficiency at such reduced speed is important. There is available an a-c. motor of the brush-shifting type that provides operation at an infinite number of speeds over a 3 to 1 or even a 4 to 1 speed range. This motor operates at high efficiency over the entire speed range. These motors can be arranged with pilot motor to provide for remote speed-control by push-button station.

Many motors of this type are in refinery service and one refining company that has been using a large number of these motors over a period of years is now arranging to install several more, including one motor rated 400/200 hp., 410/205 r.p.m.

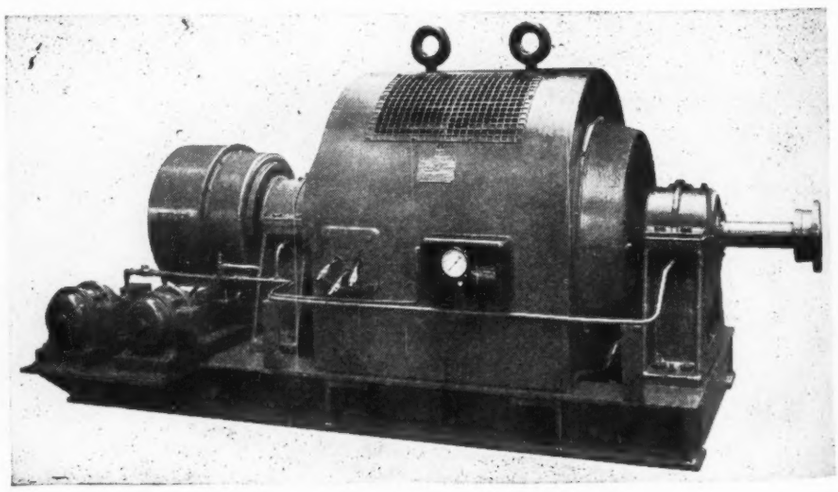
Motor control equipment for refinery service is also important. During recent years considerable development has taken place in this type of equipment. "Explosionproof" control is now available and is being widely used.

Refineries have become such large users of electric power that interrupting capacities of oil circuit-breakers and control devices must be given consideration. With this in mind, a control device has been developed that has an interrupting capacity of 50,000 kva. at 2300 volts. This device is oil immersed, all connections, terminals, and arcing parts being at least six in. under oil. The Underwriters Laboratories have not established requirements for 2300-volt control, but this type of construction has been used in hazardous atmospheres where better protection than that provided by standard forms is desired.

In some instances, dual-drive hot-oil pumps are desirable. A number of installations of this kind have been made where a pump is coupled to both an electric motor and a steam turbine. In some of these cases, the governor of the turbine is set so that it will cause the turbine to pick up the load at a speed slightly under the full-load speed of the motor. If the motor or power fails, the turbine will pick up the load as the speed drops under the full-load motor speed and it will continue to drive the pump at this slightly reduced speed, and therefore keep the oil flowing.

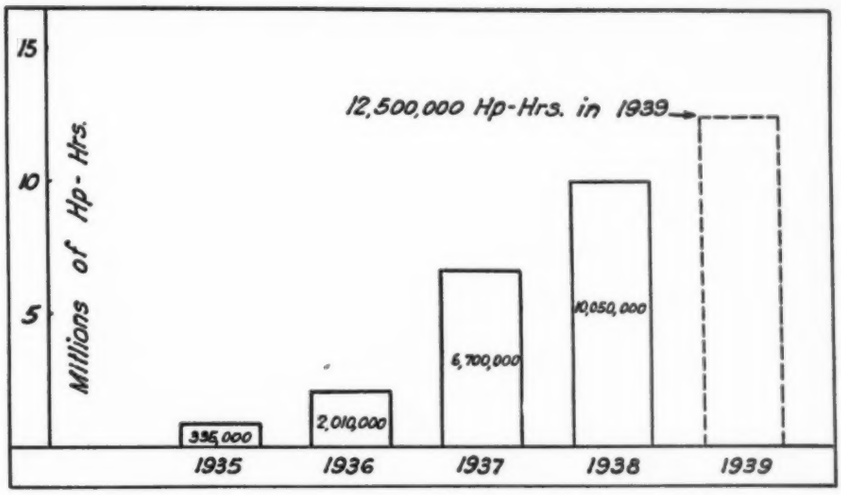
Another development of interest to refineries is that of the Pyranol transformer. Pyranol is a synthetic liquid used for transformer cooling and insulation. It is non-inflammable, and therefore provides greater safety for refinery installations.

The electrical industry is deeply interested in the operating and power problems of every division of the petroleum industry. It is hoped that from a better understanding of these problems, mutual benefits will be derived.



A 600-hp., 3600 r.p.m., 2200-volt, slip-ring induction motor having forced-feed lubrication. This unit provides 25 percent speed reduction in a gasoline pipe-line station

Fig. 1. Growth in use of purchased electric power for water-flooding, Nowata area



Electric Power Plays Important Role in Water-Flooding of Nowata Field

Of the 5200 acres under water-flood in this Oklahoma field, 3500 acres are being produced with the aid of electric power

By JERRY D. ROBERTSON
Public Service Company of Oklahoma

THE shallow Nowata field is one of the oldest and most extensive in Oklahoma, the first producers having been brought-in in 1903. This field has been extended until it now covers an area of approximately 85,000 acres, and, according to estimates, still contains approximately 3,500,000,000 bbl. of oil recoverable by secondary methods.

The first recovery in this area was by nature's own source of power, natural gas pressure in the reservoir rock. This power gradually decreased until, over a period of years, many acres were abandoned that still contained a large quantity of oil in the sand. Gas repressuring was applied with success in many instances but it now appears that a much larger recovery may be made by water-flooding.

The first water-flooding project in the Nowata area was begun about eight years ago by Burt H. Collins and Donald P. Oak on a 125-acre lease in the southern part of the field. Since May, 1931, when water-flooding was begun, this lease has produced approximately 300,000 bbl. of oil and is still producing about 60 bbl. per day.

A direct result of the experiments by Collins and Oak, and the knowledge obtained from water-flooding in the Bradford area, Pennsylvania, has been the initiating of water-flood projects by local, Pennsylvania, and New York operators. Several projects, begun in 1935 and 1936, showed what could be accomplished in this area and at the present time there are about 5200 acres in various stages of development whose total production to date is approximately 4,750,000 bbl. of oil.

JERRY D. ROBERTSON

is a native of Missouri and received his bachelor's degree in electrical engineering at Oklahoma A. & M. College, Stillwater, Oklahoma, in 1928—In the fall of the same year he began working for Public Service Company of Oklahoma in the meter department—From the meter department he was transferred to the general engineering department where he was in valuation work for several years—From this work he was made general meter superintendent—Since August, 1936, he has served as power engineer and has been in charge of the application of electric power to water-flooding projects in the Nowata, Oklahoma, field.

Of the 5200 acres under water-flood, 3500 acres are being produced with the aid of electric power. Fig. 1 shows the growth in the hp-hr. consumption for water-flooding since the beginning in September, 1935.

The installed electric hp. requirements on pressure equipment varies with the pressure required on the sand to give satisfactory intake of water in the input wells. A study of all projects in the field shows the average installed-motor hp. per acre for pressure pumps to be 0.51 hp. Auxiliary equipment, such as backwash pumps, transfer pumps, and supply pumps, varies with the type of plant used and the method of pumping the water. The average requirement in electric motors is 0.16 hp. per acre. Well-pumping requirements also vary with the type of pumping equipment used, whether individual units, geared powers, bandwheel powers, four-well pumping units, or two-well pumping units, and according to well spacing. The average requirement in electric motors is 0.48 hp. per acre. In summation then, an average of 1.15 hp. in electric motors is required per

(*Continued on Page 112*)

PURCHASED ELECTRIC

LOW COST POWER

FOR . . .

FOR . . .

FOR . . .

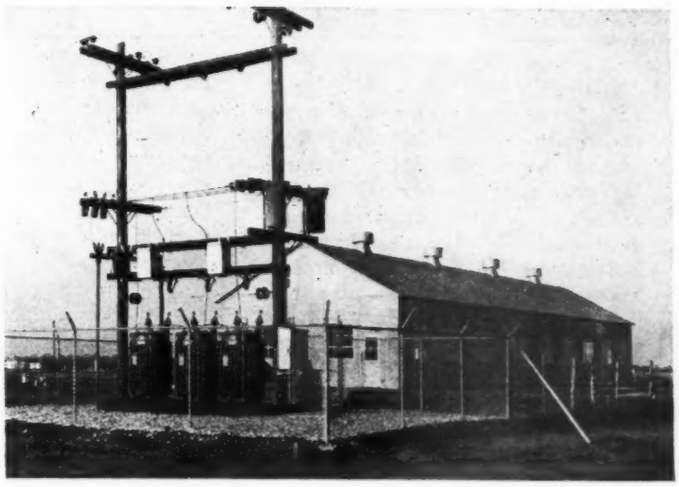
Two important questions which operators want answered when considering types of power are . . . what will it do for me . . . and what will it cost me. And every operator has a right, we believe, to be thoroughly satisfied on these points. That's why we stick to facts and present only the truth in telling our story. And you can believe us when we say that Purchased Electric Power tops them all for performance and efficiency, and that the *final cost* is amazingly low — as low or lower than for any other type power to do the same job. So why not investigate . . . learn more about the advantages of using Purchased Electric Power. You're sure to INCREASE YOUR PROFITS in the end!

ASK YOUR ELECTRIC POWER COMPANY TO GIVE YOU FACTS CONCERNING YOUR POWER PROBLEMS!

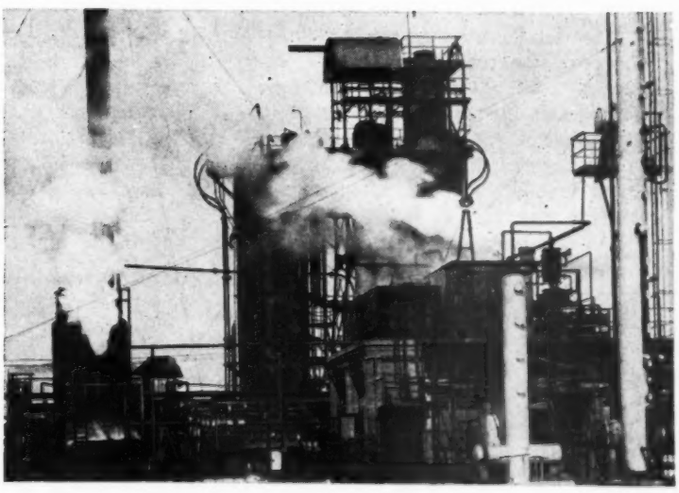
POWER

PRODUCTION

PIPE LINES

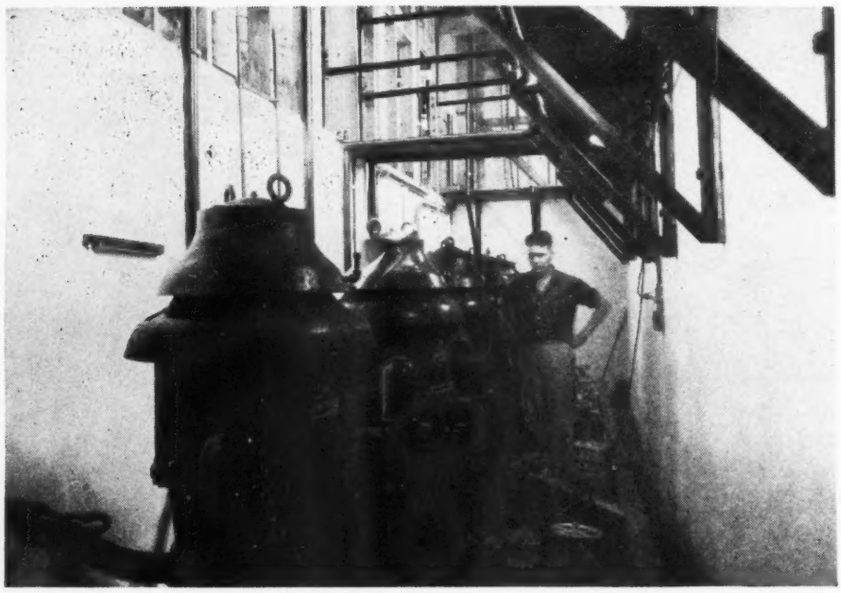


REFINING



PETROLEUM ELECTRIC POWER ASSOCIATION

Box 1498, Oklahoma City, Oklahoma



Five 75-hp. motors in pressure plant supplying water for 650 acres

(*Continued from Page 109*)

acre for a totally electrified water-flooding project.

According to records kept on flooding projects in the Nowata area, the average total hp-hr. required to produce one bbl. of oil on a totally electrified lease is 5.6 hp-hr. On a given water-flooding project where core tests indicate a recovery of 5000 bbl. per acre, 28,000 hp-hr. of energy per acre would be required. This number of hp-hr. would include the work done in injecting 50,000 bbl. of water and lifting 35,000 bbl. of fluid. Power supply is, therefore, of major importance to water-flooding if this large amount of oil is to be recovered economically.

The development of a water-flooding project naturally involves the expenditure of a large sum of money. These costs may vary from $1000 to $2000 per acre. If a cost of $1500 an acre is assumed, $300,000 would be the investment in a 200-acre lease. Water-flooding operators are constantly trying to find ways and means of reducing this cost in order to be assured of a profit that will not only cover interest and fixed charges on this investment but give an adequate compensation for the risks involved. The maximum profit from such an investment can only be realized by obtaining maximum production as quickly as possible and maintaining it until the lease is exhausted.

Water-flooding involves working with many variable factors that are difficult to determine in advance. Although it is true that the process is not new and the general principles apply in most cases, it is evident that all the experience gained in one field does not hold true for another. The porosity of the oil sand even in the same field is such that varying amounts of water are required to obtain the desired production. This may mean an increase or decrease in the amount of power required.

The amount of power required for the various stages of a particular water-flood is hard to predict and gives the operators considerable concern because it is difficult to predict exactly the pressure and quantity of water that will be required. Too optimistic an estimate may mean investment in equipment that will become idle, or, on the other hand, purchase of equipment based on experience with another lease may prove insufficient, and as a consequence additional equipment must be purchased, causing delay and loss of production.

The use of purchased electric power in water-flooding operations has helped the oil producer. It has enabled him to:

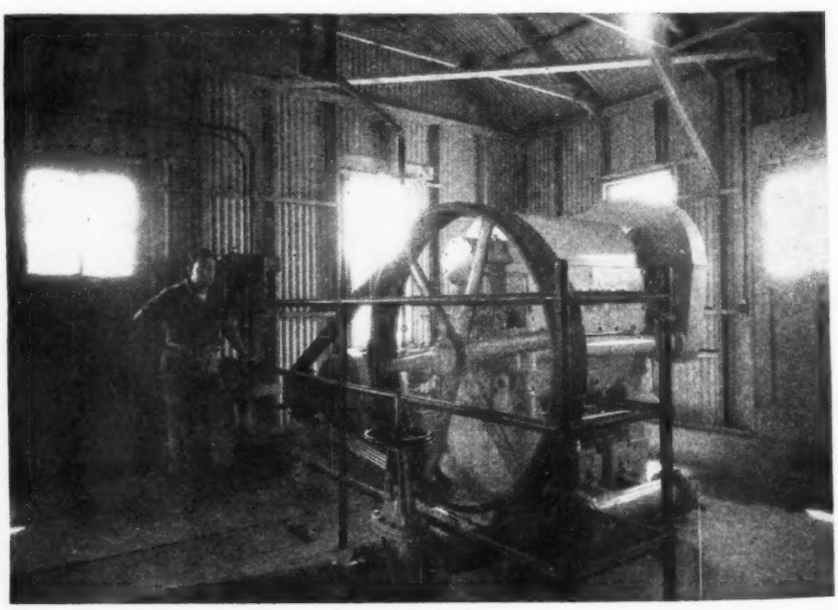
(1) Hold his initial investment to a minimum because of the low first cost of the electrical equipment, which also has a low installation cost and is easy to install.

(2) Maintain a maximum rate of production. The reliability of power supply has reduced down-time to a minimum.

(3) Reduce the hazard of possible loss contingent upon having large sums of money tied-up in excess power-plant equipment because power requirements cannot be accurately forecast. When purchased electric power is used only enough equipment for immediate requirements need be installed, which can be added to as the project develops.

After a water-flood has been in operation for some time, another problem that faces the operator is the disposal of the salt water that is obtained along with the oil. Some operators turn the salt water back into the fresh water supply and run it through the treating plant. Considerable difficulty has been encountered in some instances owing to the salt water disturbing or hardening the filter bed. Some operators install salt-water disposal plants and return the salt water, under pressure, to

A 50-hp. motor driving a triplex water pump, supplying water for 100 acres



The Answer

FOR ECONOMY IS...

Electric Service from Your Utility

1. Low Initial Cost

. . . Also installation, maintenance and operating costs are lower.

2. Greater Efficiency

. . . is insured during constant or intermittent service.

3. Controlled Consumption

Electricity insures the exact amount of power to meet your needs at all times—and you pay ONLY for the power used.

4. Higher Salvage Value

There is less depreciation to electrically-powered equipment and the cost of reconditioning is always moderate.

PANHANDLE POWER & LIGHT CO.
BORGER, TEXAS

KANSAS CITY POWER & LIGHT CO.
KANSAS CITY, MO.

an almost depleted flood. In some instances production has been known to increase when the salt water was turned in on a declining flood. This type of salt-water disposal plant is easily and quickly installed because of its portable nature. Electric service for its operation is easily obtained by extending the distribution lines. When desired, the entire unit, including the distribution system, may be moved to a new location.

The power company serving the Nowata area has endeavored to aid the operator by providing factual data on all types of power applications. The initial undertaking, which was in coöperation with a supply company representative, was a series of dynamometer tests on a complete central-power system to determine the hp. actually required to pump a well and the various power losses at different points throughout the system. Power input and losses were determined on the polished rod, through the jack, through the rod-lines, and through the geared power by means of a Kemler well-weighing instrument and strain gauge, provided and operated by the supply company. The hp. input to the power was determined by using an Esterline-Angus recording wattmeter.

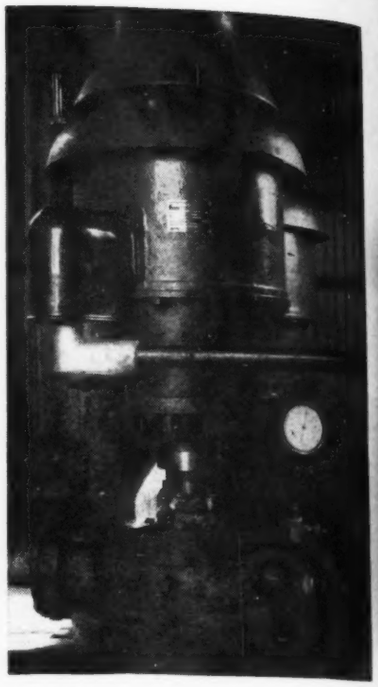
The wells tested were on an average 520 ft. in depth, 2-in. working barrels were used, and the sucker rods were ⅝ in. in diameter and had a total weight of 580 lb. The wells were pumped at a speed of 15.2 s.p.m.

The shallowness of these wells and the light-weight of the sucker rods caused considerable variation in length of stroke of the rod lines between the power and the jacks, the longer rod lines having the greater loss in stroke-length. This was because the rods in the well, when dropped back into the hole, were not heavy enough to overcome friction in the rod supports and the longer rod-lines sagged. On the upstroke at the power, the sagging due to friction, had to be picked-up before upstroke on the jack began, thus creating a loss in stroke at the jack. A summary of the results obtained are as follows:

Average hp. per well on polished-rod	0.28
Average hp. requirements on the rod-line near the jacks	0.423
Average efficiency of this style Oklahoma jack	66.2%
Average rod-line loss in hp. for 18,371 ft. of rod-line (av. length per well 612 ft.) per 100 ft. of rod-line	.04
Summation of hp. input to rod-lines at power	19.17
Hp. input to motor	28.14
Overall efficiency of gear power and drive	68.1%
Total hp. demand at polished-rod for 30 wells	7.8
Total hp. input to system	28.14
Overall efficiency of system	27.8%

From this test has resulted the development and design of a smaller and more efficient jack and a smaller and more efficient individual well-pumping unit.

Some time later, the value of the data obtained from the test was demonstrated in estimating the kw-hr. per month for another central power, situated in Rogers County. On this project, there were 30 full-time wells and five part-time wells, having a total of 19,080 ft. of rod-line operating at 18.4 s.p.m. It was estimated that the demand would be 22.2 kw. and that the monthly consumption would be 14,556 kw-hr. Under actual operating conditions the demand was 25 kw. and the actual kw-hr. used per month were 14,640.



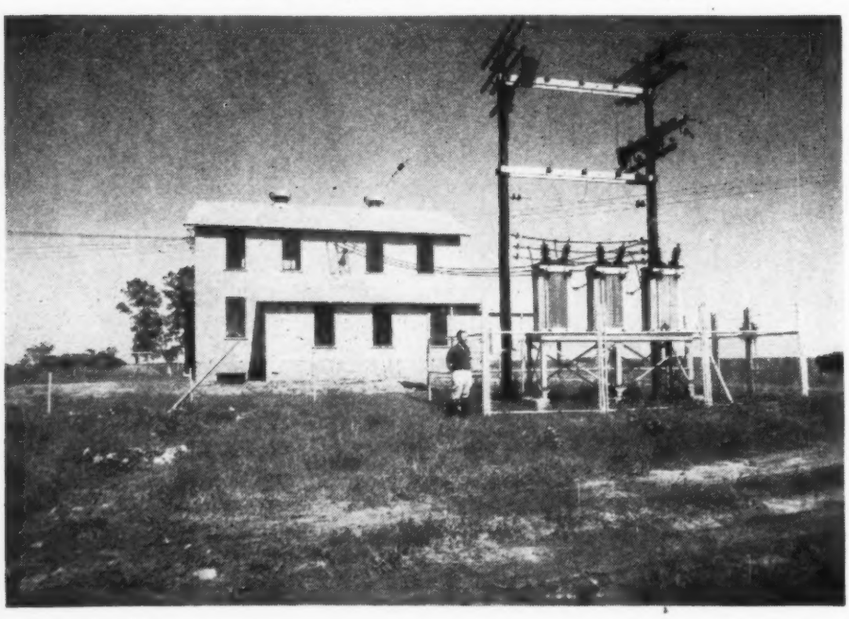
Two 75-hp. motors driving pumps in a salt-water disposal plant

Three months later, it was decided to conduct a 48-hour fluid test on the same lease, under the same operating conditions as were encountered when running the dynamometer test. In conducting this test, a record of the kw-hr. used, the length of time each well was pumped, the bbl. of oil and water pumped, was kept. Depths of wells, s.p.m., length of stroke in each well, size of working-barrel, specific gravity of oil and water, and the lead-line pressure were tabulated. From these data the following were determined:

Overall efficiency for entire system	25.9%
Bbl. fluid pumped per kw-hr.	3.46
Ratio of bbl. of water to bbl. of oil pumped	4.7
Ratio of actual to theoretical pump efficiency	52%

As already stated, the overall efficiency of the system as obtained in the dynamometer test was found to be 27.8 percent as compared with 25.9 percent by the fluid test. This difference in efficiency can be partly explained by the ratio of actual to theoretical pump efficiency. In other words, the working-barrel part of the time is

Forest Producing Corporation No. 4 water-flooding plant



WHY You Get Lower Well-pumping Costs with Electric Drive

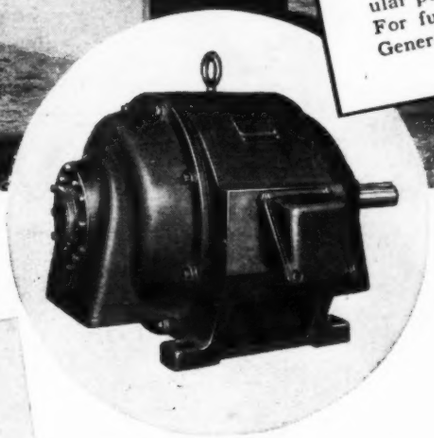
Electric drive has these advantages

1 Low first cost
2 Small maintenance expense
3 Simple and economical installation
4 Operating characteristics to meet all kinds of pumping loads
5 Automatic starting and stopping according to schedule
6 Economical consumption of power
7 Long life and high salvage value
8 Portability
9 Easy on the mechanical equipment

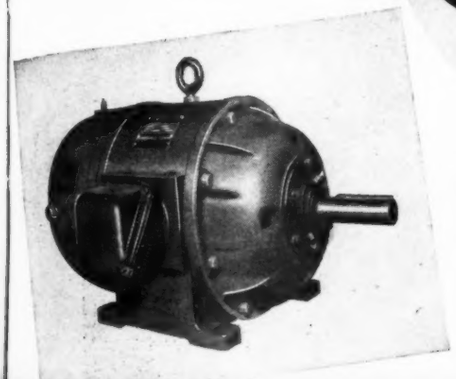
THE careful design and the sturdy construction of G-E equipment are known throughout the oil industry. You can't go wrong when you buy G-E motors and control directly, or when you SPECIFY GENERAL ELECTRIC at the supply house.

Remember: G-E oil-field specialists will be glad to study your particular pumping requirements and show you how they can best be met. For further information, get in touch with the nearest G-E office. General Electric, Schenectady, N. Y.

One of 38 G-E splashproof induction motors driving pumping rigs on a lease in Southwestern Texas



G-E splashproof motor for well-pumping service. This motor meets all the requirements of a pumping-rig drive in areas where medium weather conditions are encountered



G-E totally enclosed, fan-cooled motor for well-pumping service. This motor is protected against rain, dust, and dirt and is particularly suited for long-time operation under any type of weather conditions. Like the G-E splashproof motor, it can be furnished in double- or triple-rated design to handle a variety of pumping loads

G-E 20-hp splashproof induction motor driving pumping rig on an Oklahoma oil property

GENERAL ELECTRIC

011-356

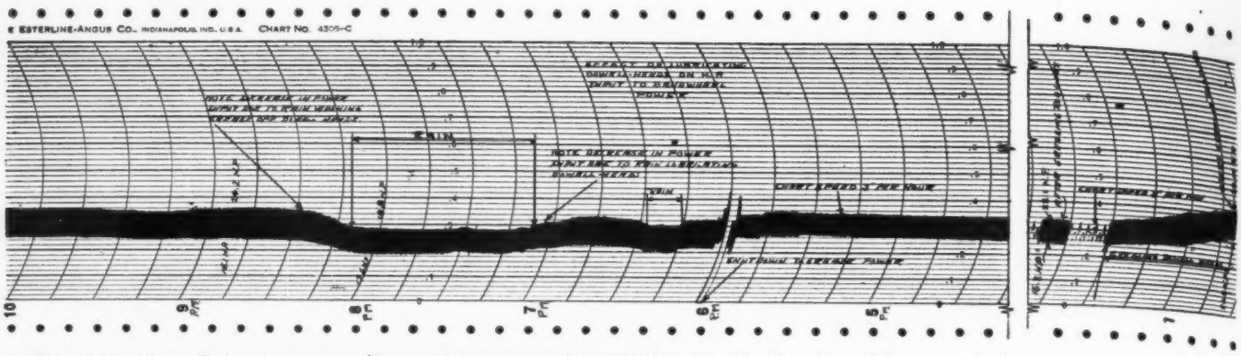


Fig. 2. Portion of chart on recording wattmeter used in efficiency test of motor-driven central-power pumping unit

only partly filling each stroke during the pumping period of the well.

The next study was made on a bandwheel central power on a lease pumping an average of 23 wells, 24 hours per day. This lease is in Rogers County, Oklahoma. The average fluid level was 470 ft. The same procedure was used in making this fluid test.

While making this test, it was apparent that the s.p.m. could be reduced from 18 to 15 and the volume of fluid pumped satisfactorily. So the test was divided in two parts: the first at 18.4 s.p.m., and the second at 15.2 s.p.m. This change in s.p.m. was made by changing the sheave size on the motor.

The following results were obtained in the test:

	At 18.4 s.p.m.	*At 15.2 s.p.m.*
Overall efficiency of entire system	15.1%	18.5
Bbl. of fluid pumped per kw-hr.	2.34	2.87
Ratio of bbl. of water to bbl. of oil pumped	11.5	10.2
Ratio of actual to theoretical pump efficiency	36.9	45.4

By changing from 18.4 s.p.m. to 15.2 s.p.m., the overall efficiency was increased from 15.1 to 18.5 percent. The number of bbl. of fluid per kw-hr. was increased from 2.34 to 2.87 and the ratio of actual to theoretical pump efficiency was increased from 36.9 to 45.4 percent. This increased efficiency, however, was of far greater interest to the operator than at first might be thought, because it reduced the power bill $20.00 per month. This change in operation had reduced the power consumption approximately 2500 kw-hr. per month.

All this saving in power, however, was not a result of changing the s.p.m. of the wells. Before beginning the tests, the power was balanced as nearly as possible. After balancing the power, it was decided to grease all the rod-lines and carriers to determine how much this would reduce the hp. input to the motor driving the bandwheel. The results were surprising, as shown by the accompanying chart. The maximum input to the motor before greasing was 28.1 hp., the minimum 20.8 hp. After greasing, the maximum input to the motor was 22.1 hp., and the minimum 16.2 hp., a reduction in maximum input of 6 hp., or 21.5 percent, and a reduction in minimum input of 4.6 hp., or 22.1 percent.

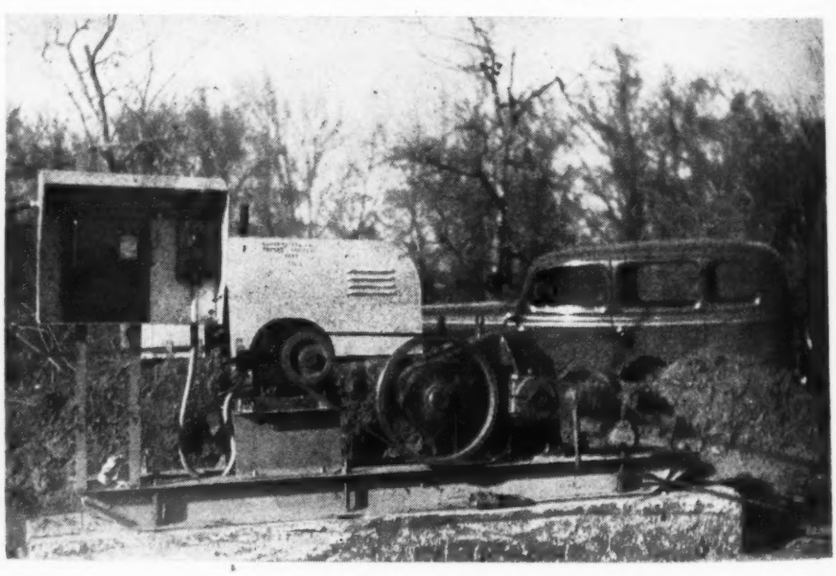
At about 6:15 on the evening of this rod-line test it rained. On the chart a drop in power input is shown to have occurred when it rained; apparently the water served as a lubricant. At 6:30 o'clock the hp. input increased—it had stopped raining. At about 7:00 o'clock it began raining again and rained for approximately 45 minutes. At about 8:10 p. m., it can be noted on the chart, the hp. input began to increase, even higher than it was at 4:30 p.m. As shown, the input to the motor at 8:00 p.m. was: maximum 18.8 hp., minimum 12.6 hp., and at 8:45 p.m. had advanced to 24.2 hp. maximum and 16.1 hp. minimum, an increase of 5.4 hp. and 3.5 hp., respectively, in 45 minutes after the rain stopped. The maximum input was 1.2 hp. greater after the rain than before, owing to the fact that the rain washed away a part of the grease on the rod-line carriers.

On another test on a lease in Kansas the same procedure of greasing rod-lines and carriers was followed. The reduction in hp. to the motor was 2.6 on the maximum and 4 hp. on the minimum, an average of 3.3 hp., or 10.8 percent. The percent reduction was not so great as on the other test, because the number of long rod-lines was less.

The results of the above tests on lubricating rod-lines reveal that the production man can reduce his operating costs by using the proper grease and keeping the rod-line carriers well-greased at all times.

Several operators in the Nowata field are now purchasing rod-line carriers having a hole in the center that can be

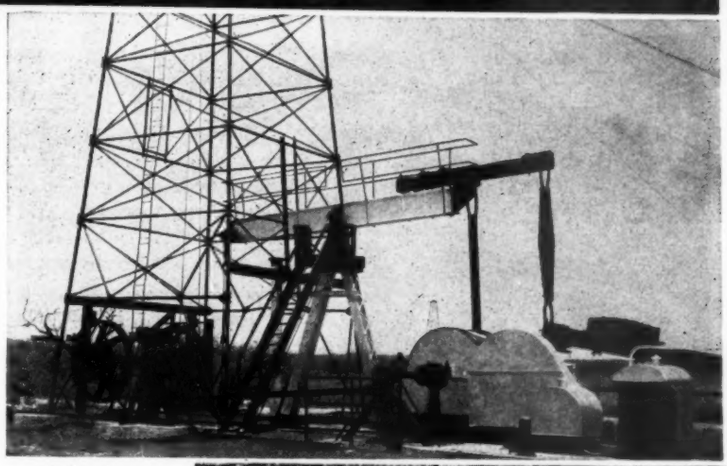
A 3-hp. motor driving a four-well pumping unit



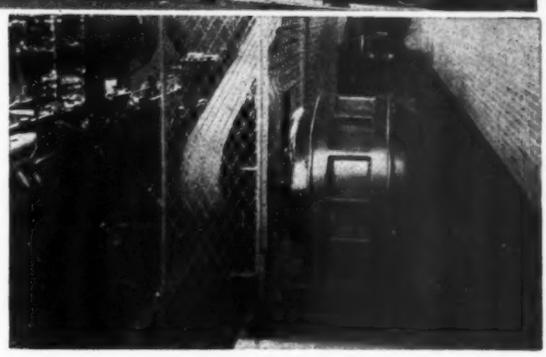
SAVE MONEY *with* PURCHASED ELECTRIC POWER

• In every phase of the oil industry, operators are finding that Purchased Electric Power is not only dependable and flexible in its applications, but also effects substantial savings in both investment and operating costs. In addition, there are the savings that accrue from the fact that electrical installations can be made in days instead of weeks, cooling water problems are eliminated, salvage value of equipment is high and labor costs are held to a minimum. Then, too, maintenance costs are greatly reduced, accurate cost records are easily kept and electrical units are easily and quickly moved from one job to another.

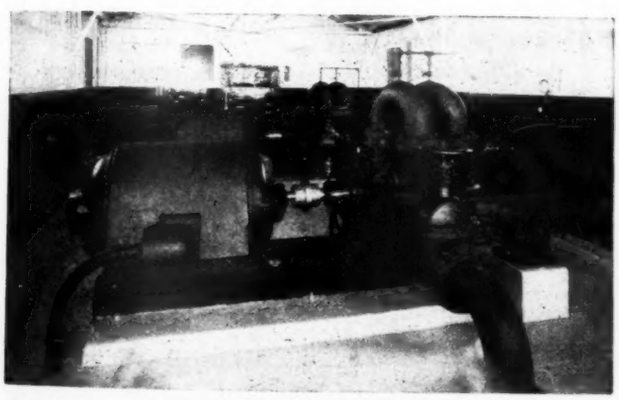
Consult our power engineers—they have the facts and figures to show you how the efficiency and economy of electric power means more profit to you.



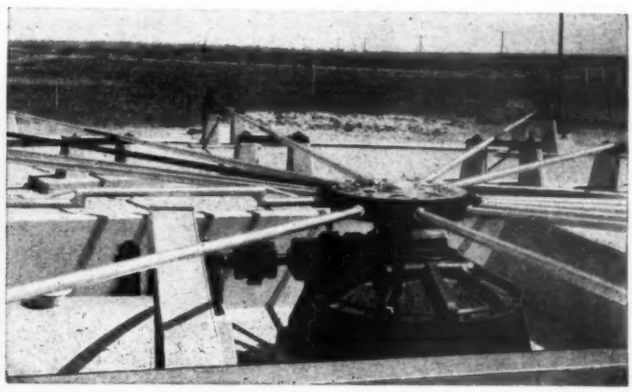
(above) This well in south Howard County is fully automatic in operation and shows a remarkably low cost per barrel of oil recovered over a period of several years.



Two of a battery of electric motors in an air compressor room in a large North Texas refinery—economical operation is the main reason for this installation.

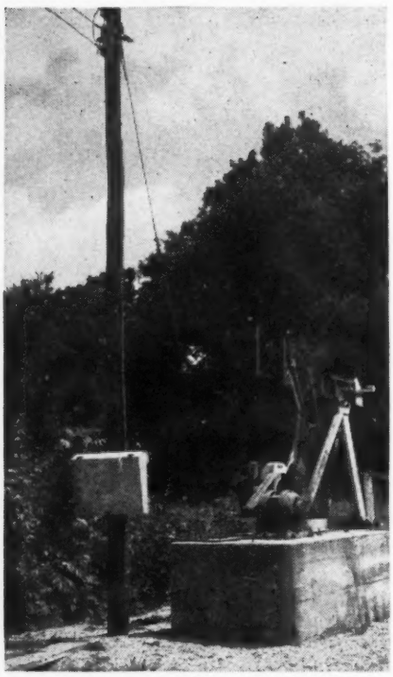


Two 400-hp., automatically controlled, electric pumping units in a pipe line station in Ector County—one of the most efficient installations in this section of West Texas.



One of several central power pumping units on a lease in south Howard County. The operators of this and adjoining leases heartily endorse Purchased Electric Power for well pumping.

TEXAS ELECTRIC SERVICE COMPANY



A two-well pumping unit

filled with oil and a wick placed in the hole. The wick, rubbing against the rod-line as it slides back and forth over the rod support, keeps the rod lubricated. With this arrangement, a thinner oil can be used for lubrication, reducing friction to an even greater extent.

The next test was on individual pumping units. The wells tested were being pumped by jacks driven by 1½-hp., 440-volt, 3-phase motors. The average depth of the wells was 529 ft., the fluid level 497 ft. The average s.p.m. was 26.7 with an average length of 14 in. To get a representative test, four different wells, producing varying amounts of water and oil, were used, two tests being made on one well at different s.p.m.

The following results were obtained:

Average overall efficiency of the unit	41.3%
Bbl. of fluid pumped per kw-hr.	6.8
Average peak hp. input to motor	1.53
Average hp. input to motor	0.96
Ratio of actual to theoretical pump efficiency	85.9%

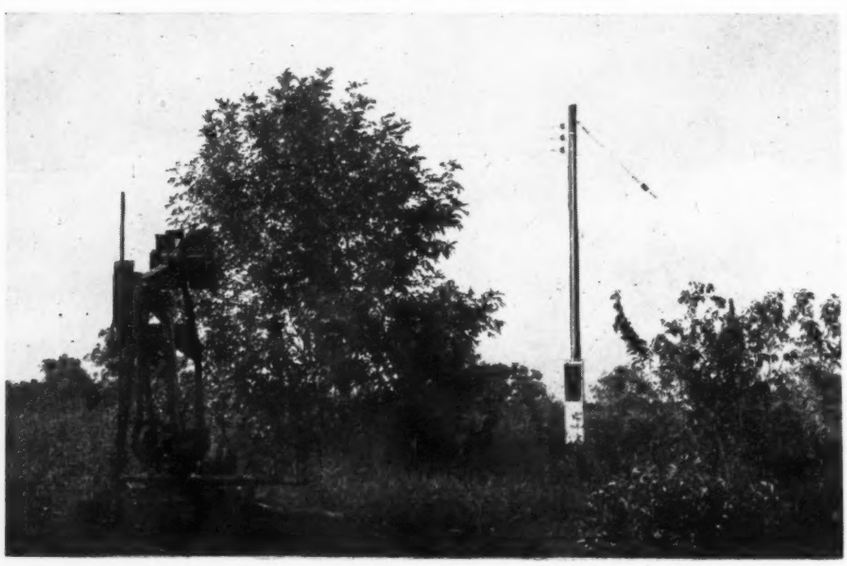
The outstanding facts of this test were the increased overall efficiency, the greater number of bbl. of fluid pumped per kw-hr., and the higher ratio of actual to theoretical pump efficiency. The maximum efficiency of any central power system tested was 27 percent, as compared with 41.3 percent for the individual pumping unit. The maximum bbl. of fluid pumped per kw-hr. for any central power was 4.01, as compared with 6.8 for the individual unit. The highest ratio of actual to theoretical pump efficiency was 52 percent for central powers, as compared with 85.9 percent for the individual pumping unit.

While making this test, it was decided to experiment with one of the wells that was being pumped by a jack. The 1½-hp. motor was replaced by a 1-hp. motor. The s.p.m. were increased from 24 to 33. The results were as follows:

Overall efficiency	increased from 36.3	to	45.8	percent
Bbl. of fluid pumped per kw-hr.	increased from 6.54	to	8.28	
Average hp. input to motor	increased from 0.67	to	0.88	
Ratio of actual to theoretical pump efficiency	increased from 81	to	82.5	percent
Bbl. of fluid pumped per 24 hours	increased from 79.5	to	114	

Typical 440-volt distribution system used in water-flooding operation

Individual pumping unit and 440-volt line

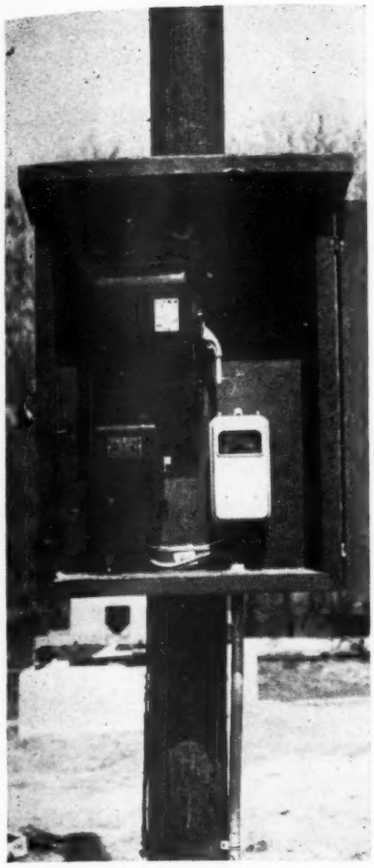


This experiment tends to show the flexibility of the individual pumper, and to what extent it is possible to increase the s.p.m. without loss in overall efficiency.

Numerous other tests have been conducted on different types of pumping equipment. The results of each test in bbl. of fluid pumped per kw-hr. are summarized in the table on page 119.

The power company's purpose in conducting these tests was to obtain data that assist the production man in determining the power required in pumping oil wells. They should not be construed as favoring one type of pumping over another, because there are many other factors to be considered.

The power company serving the water-flooding area provides operators with complete information and design data for laying-out an economical dis-



Protective and control equipment for individual pumping unit employing time-clock to regulate intermittent pumping

		Bbl. per kw-hr.	*Depth in ft.*
1.	Geared power, old style, underslung, one eccentric, long rod-lines, average	3.44	520
2.	Bandwheel power, double eccentric, long rod-lines using jackshaft for speed reducer	2.87	470
3.	Small 30-hp. geared power, new type	3.15	518
4.	Small 30-hp. geared power, new type	2.63	750
5.	Two-well pumping unit, one unit on well, second well 330 ft. distant	4.01	500
6.	Individual well pumpers	6.8	500
7.	Four-well pumping unit	5.7	526

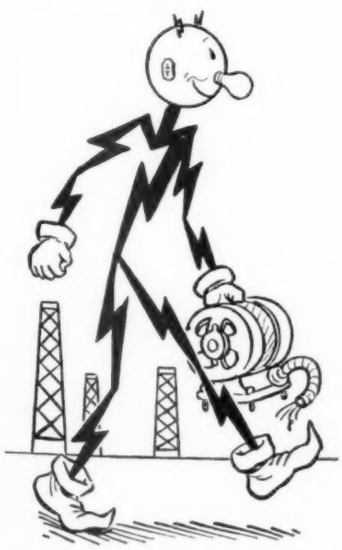
tribution system. One particular system was designed to operate all pumping wells on 700 acres from two 13,200-volt to 440-volt substations. This service is always available to operators without cost.

The data collected during the last two years make it possible to compute the complete cost to serve any type of pumping unit. For instance, the complete cost of a distribution system for pumping 16 oil wells on 40 acres, using individual pumping units, was found to be $0.22 per ft. The average cost of equipment, from the secondary to the motor on the unit, including starting and protective equipment, was found to be $40.00 per well.

This information on water-flooding power applications was obtained through the coöperation of the producers in the field. It should be helpful to the operator planning a new project. The power company engineers find themselves in the position of fact-finders for data of this kind, because they are in contact with the production men, who use all types of equipment, and have facilities and testing apparatus for obtaining first-hand information.

"Let's Get Together . .

You Want Profits..I Want Work!"



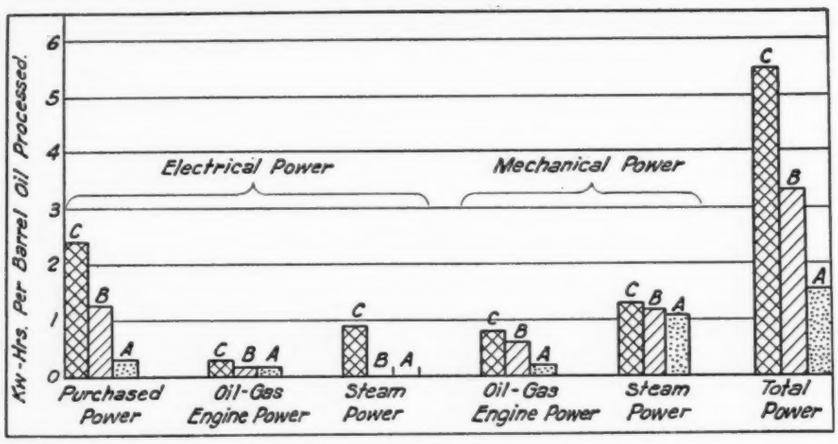
Our network of transmission lines cover a 45,000 square-mile area in 49 West Texas counties, most of which have oil and gas development. Electric Service for pumping, drilling, booster stations, etc., is available. Experienced power engineers will help you with your power problems.

West Texas Utilities Company

GENERAL OFFICE: Abilene, Texas (Phone 3-2-5-1)

DISTRICT OFFICES

San Angelo McCamey Quanah Ballinger Childress Cisco Dalhart Stamford



Graphic representation of various types of power required to refine crude oil, based on data contained in Tables 1, 2, and 3. A—Skimming plant. B—Skimming and cracking plant. C—Complete plant

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

Analysis of Power Requirements in Refinery Operations

Study shows modern refinery uses an average of 0.42 hp. more per bbl. of oil processed than older-type refinery—modernization of older plants promises potential market for electric sales of 339,000,000 kw-hr. per year

By W. H. STUEVE*
Oklahoma Gas and Electric Company

THE art of refining crude oil had its inception with the discovery of oil in the Pennsylvania oil fields 75 years ago. The products at that time were principally kerosene and lubricating oil, but with the extension of electric facilities for lighting, and later the use of motor cars, gasoline has now become one of the main products. In the early development it was possible to extract about 25 percent to 30 percent of the crude in the form of gasoline. The residue was disposed of at extremely low prices. The development of heat- and pressure-resisting metals to withstand temperatures of 1000°F. and pressures of 1000 lb. aided the further recovery of gasoline content in the crude oil. Today the so-called cracking process enables a recovery of 50 to 70 percent of the original charge of crude oil, or as much as 30 gal. of gasoline from 42 gal. of crude oil. Even greater recoveries of gasoline by catalytic processes recently developed are reported.

*Member of Industrial Power Committee, Edison Electric Institute.

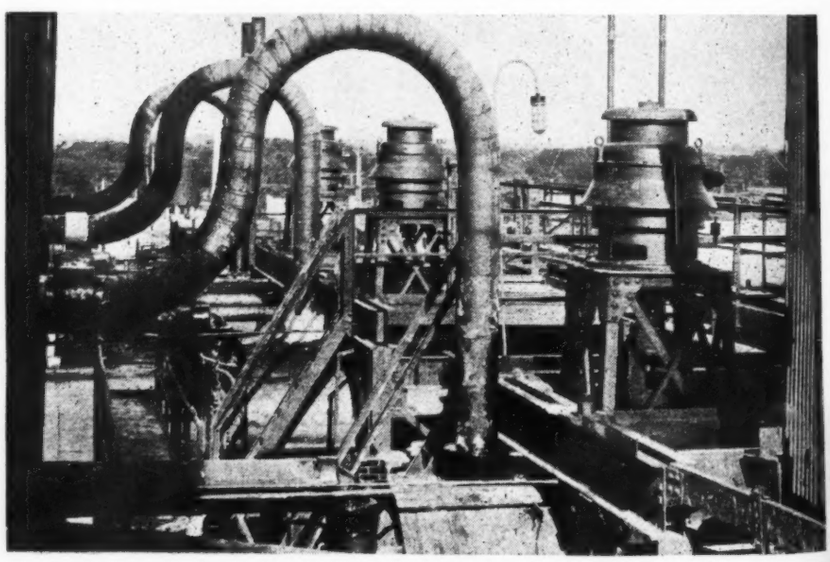
Refinery Locations

There are in the United States 647 refineries of all classes, having a daily capacity of 4,163,000 bbl.; however, only 422 of this number, having a total daily capacity of 3,749,000 bbl., were active or engaged in the actual refining business as of January, 1936.

The distribution of active oil refineries by states is tabulated in Table 1. Table 2 shows the distribution of refineries for the various districts of the United States.

Progressive Use of Electricity

Direct-acting steam pumps were originally used for pumping condensing water, crude oil, and the products of refining. This was done largely to eliminate the fire hazard, and as great quantities of steam were necessary for the distillation processes, the steam required for pumping was considered on an incremental basis and was appar-



Outdoor installation of three 30-hp. vertical motors driving circulation impellers in oil-cracking process

NOW EXPLOSION-RESISTING MOTORS

500 HP • 3,600 RPM AND LARGER

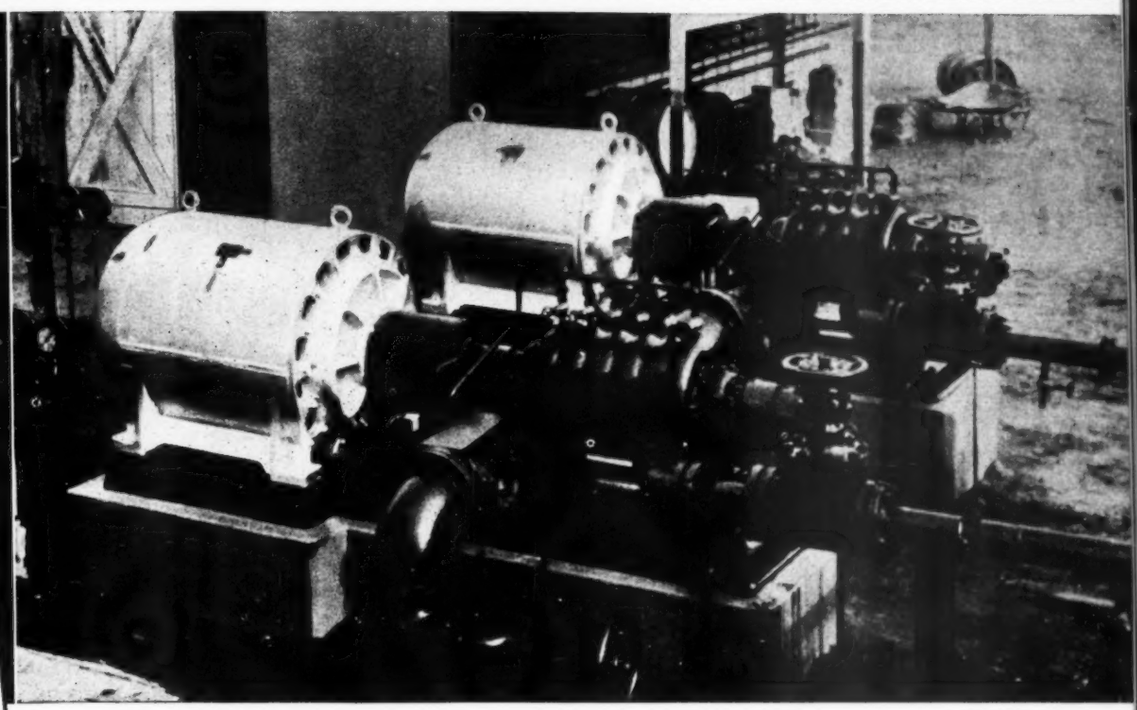
THESE FEATURES MEAN:

Greater Safety

Less Maintenance

FOR PIPE LINE PUMPING INSTALLATIONS

1. Dual Ventilation (Heat exchanger principle)
2. Sleeve Bearings Permanently Aligned
3. Radio Frequency Tested Insulation
4. Dynamically Balanced Rotors



Two Westinghouse explosion-resisting motors that are delivering trouble-free service on pipe line pumping.

The reliability, safety and low maintenance cost of Westinghouse explosion-resisting motors has been adequately proved by pipe line installations requiring less than 500 hp. Now, Westinghouse makes available the same proved mechanical design and electrical construction in motors of 500 hp — 3,600 rpm and larger.

These motors are designed and built for centrifugal pump applications on class I group D hazardous locations. The totally enclosed construction that makes safe operation possible in explosive atmosphere also provides a weather-proof enclosure.

Westinghouse explosion-resisting motors may be started at either full or reduced voltage. With normal starting current they deliver normal starting torque. Where required, they can be designed to deliver either normal or low starting torque with low starting current.

The explosion-resisting motor is only one of the many pieces of equipment Westinghouse has developed for the safe, economical use of electrical power in the petroleum industry. For equipment you can depend upon to give trouble-free service and long life, consult the Westinghouse representative in your district.

• • •

Westinghouse Electric & Manufacturing Company
East Pittsburgh, Pa.

J-10145

W WESTINGHOUSE ELECTRIC

Westinghouse

EXPLOSION-RESISTING MOTORS

TABLE 1

Location of Refineries by States (January 1, 1936)

State	Number				Capacity (bbl. per day)			
	Operating	Shut down	Building	Total	Operating	Shut down	Building	Total
Alabama	1	.....	.....	1	4,000	.....	.....	4,000
Arkansas	7	3	.....	10	37,200	10,500	.....	47,700
California	60	15	1	76	799,160	47,950	12,000	859,110
Colorado	7	3	.....	10	4,940	2,480	.....	7,420
Delaware	1	.....	.....	1	2,000	.....	.....	2,000
Georgia	2	.....	.....	2	9,000	.....	.....	9,000
Illinois	11	2	.....	13	123,000	8,500	.....	131,500
Indiana	6	.....	.....	6	203,200	.....	.....	203,200
Kansas	22	3	1	26	174,100	3,650	1,000	178,750
Kentucky	9	2	.....	11	26,600	2,700	.....	29,300
Louisiana	12	5	2	19	183,000	19,350	15,000	217,350
Maryland	3	.....	.....	3	55,000	.....	.....	55,000
Massachusetts	2	.....	.....	2	34,500	.....	.....	34,500
Michigan	12	1	5	18	37,800	1,000	8,300	47,100
Mississippi	.....	2	.....	2	.....	1,050	.....	1,050
Missouri	1	2	.....	3	18,000	5,500	.....	23,500
Montana	17	13	.....	30	21,645	4,955	.....	26,600
Nebraska	3	.....	1	4	498	.....	72	570
New Jersey	6	.....	1	7	255,600	.....	6,500	262,100
New Mexico	8	1	1	10	6,900	100	500	7,500
New York	6	2	.....	8	57,000	850	.....	57,850
Ohio	12	2	.....	14	107,930	2,500	.....	110,430
Oklahoma	32	18	.....	50	252,420	37,439	.....	289,859
Pennsylvania	31	8	.....	39	291,675	18,800	.....	310,475
Rhode Island	2	.....	.....	2	7,000	.....	.....	7,000
South Carolina	1	.....	.....	1	6,500	.....	.....	6,500
South Dakota	4	.....	1	5	226	.....	27	253
Tennessee	1	.....	.....	1	100	.....	.....	100
Texas	111	100	1	212	961,870	192,429	1,500	1,155,799
Utah	2	3	.....	5	7,500	500	.....	8,000
Virginia	1	.....	.....	1	2,000	.....	.....	2,000
West Virginia	5	1	.....	6	14,500	2,500	.....	17,000
Wyoming	24	24	1	49	44,971	4,459	2,000	51,430
Total	422	210	15	647	3,749,835	367,212	46,899	4,163,946

TABLE 2

Location of Oil Refineries by Areas or Districts

	Number				Capacity (bbl. per day)			
	Operating	Shut down	Building	Total	Operating	Shut down	Building	Total
East Coast	25	.....	1	26	617,600	.....	6,500	624,100
Appalachian	39	13	.....	52	152,875	24,650	.....	177,525
Ind., Ill., Ky., etc.	47	5	5	57	462,930	12,200	8,300	483,430
Okla., Kans., Mo., etc.	55	23	1	79	444,520	46,589	1,000	492,109
Texas Inland	91	96	.....	187	328,070	175,929	.....	503,999
Texas Gulf Coast	20	4	1	25	633,800	16,500	1,500	651,800
La. Gulf Coast	5	.....	.....	5	136,000	.....	.....	136,000
Ark. and La. Inland	15	10	2	27	88,200	30,900	15,000	134,100
Rocky Mountain	65	44	4	113	86,680	12,494	2,599	101,773
California	60	15	1	76	799,160	47,950	12,000	859,110
Total	422	210	15	647	3,749,835	367,212	46,899	4,163,946

ently economical. The first application of electric power was for lighting and also to avoid fire hazard caused by open-flame torches or gas-lighting. The introduction of the induction motor and centrifugal pump led to the consideration of electric power for water pumping, for large quantities of water were required, and pumping stations and spray ponds could be installed some distance from the stills and other refining operations where the elimination of fire hazard was considered important. Later the explosionproof motor again widened the field of potential use of motors. Today oil refineries perform about one-third to one-half of their operations with electric motors.

Types of Refineries

Oil refineries can generally be divided into three classes, or types, according to the nature of refined products produced, as follows:

A. Skimming refineries that recover 25 to 30 percent of the gasoline content of crude oil by low pressure-temperature distillation.

B. Skimming and cracking refineries that first recover all gasoline content possible by low pressure-temperature distillation then by further application of heat and pressure to the residue are able to recover about as much additional gasoline as was possible with the simple skimming process.

C. "Complete" refineries that first recover all gasoline possible by both low pressure-temperature skimming and high pressure-temperature cracking and then recover lubricating oil from the residue by rectification and refrigeration.

Although the daily capacity of the

TABLE 3

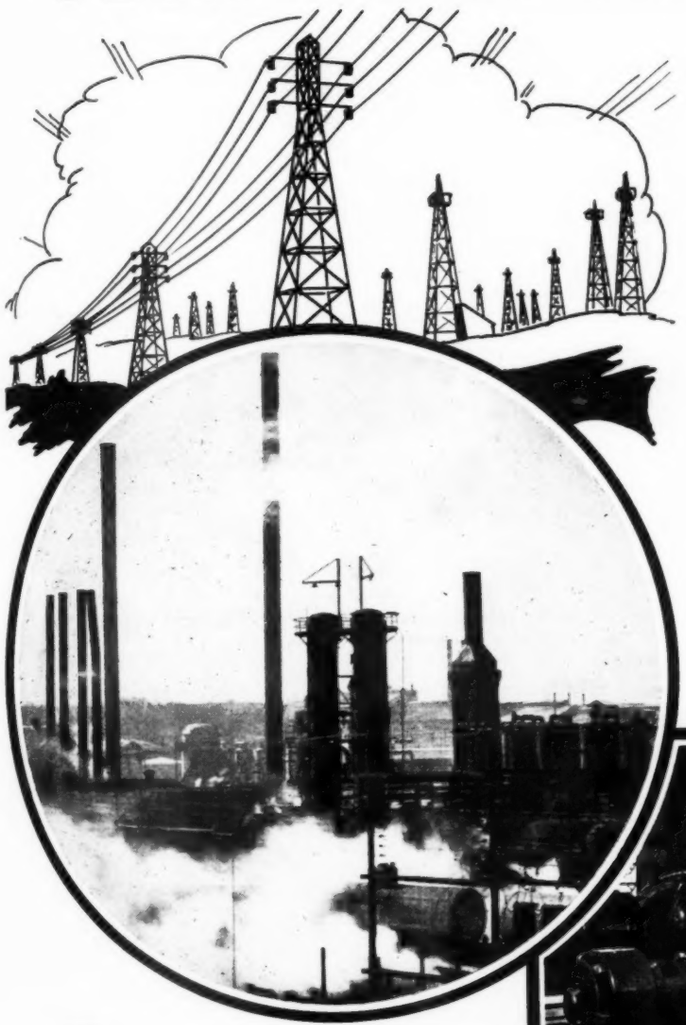
"Skimming" Oil Refineries (Class A). Energy (Electrical and Mechanical), Water, and Steam Requirements

Refinery	Rated capacity, bbl./day	Actual annual average throughput, bbl./hr.	Average "Electric Power" requirements, kw-hr./bbl. of crude input				Average "Mechanical Power" requirements, equivalent kw-hr./bbl. of crude input			Total electric and equiv. mech. power, kw-hr./bbl.	Hp. of electric motors/bbl. of hourly throughput	Water requirements			Steam requirements		
			Purchased from utility	Generated in private plant			Gas engine	Oil engine	Steam engines or turbines			Condensing water		Total makeup, gal. per min.	Lb./hr.	Boiler pressure, lb.	Degree superheat
				Gas engine	Oil engine	Steam turbine						Actual, gal. per min.	Bbl. water/bbl. oil				
A	400	13	0	0	0	0	.88	0	.5	1.38	0	200	18.0	....	800	90	0
B	1,000	35	1.57	0	0	0	0	0	1.43	3.00	2.6	250	8.6	....	6,000	150	0
C	1,000	33	1.21	0	0	0	0	0	1.37	2.58	2.1	300	10.9	....	5,500	100	0
D	2,000	66	.23	0	0	0	0	0	.91	1.14	.7	250	4.5	....	3,500	105	0
E	2,500	83	.16	0	0	0	0	0	1.27	1.43	.25	300	4.3	....	4,000	125	0
F	3,000	100	.15	0	0	0	0	0	1.50	1.85	.20	330	4.0	....	7,400	130	0
G	3,000	63	.05	0	0	0	0	0	1.60	1.65	.60	370	7.0	....	2,500	125	0
H	3,000	111	.36	0	0	0	0	0	1.00	1.36	.90	500	5.4	....	6,500	150	0
I	3,500	104	.24	0	0	0	0	0	1.10	1.34	.43	500	5.8	....	6,500	130	0
J	3,500	112	.48	0	0	0	0	0	.53	1.01	1.55	1,400	15.0	....	10,500	125	0
K	5,000	108	.53	0	0	0	0	0	1.40	1.93	1.02	620	6.7	....	6,500	150	0
L	5,000	146	.11	0	0	0	0	0	1.55	1.66	.61	770	6.3	....	7,500	125	0
M	5,000	208	0	0	0.5	0	0	0	.80	1.30	0	1,300	7.5	....	24,000	150	0
N	6,000	166	.18	0	0	0	.19	0	.90	1.17	.30	1,000	7.2	....	10,000	125	0
O	6,500	200	.26	0	0	0	0	0	1.90	2.16	.51	1,020	6.1	....	18,000	100	0
P	6,500	166	.10	0	0	0	.25	0	.90	1.25	.63	610	4.4	....	10,000	125	0
Q	7,500	150	.88	0	0	0	0	0	.84	1.72	2.60	600	4.8	....	15,000	135	0
17	64,400	1,864††	.30*	0	.056*	0	.045*	0	1.155*	1.556*	.9*		6.6*		78 lb./bbl.*		

*Weighted average.
††Percent throughput of nominal capacity = 69.5

PURCHASED *Electric* POWER

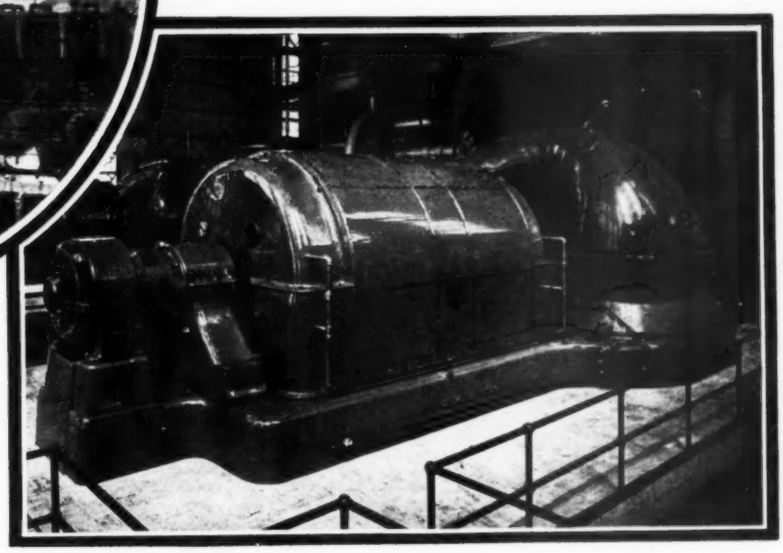
★ A BASIC PROFIT FACTOR IN THE PETROLEUM INDUSTRY FROM WELLS THRU REFINERY



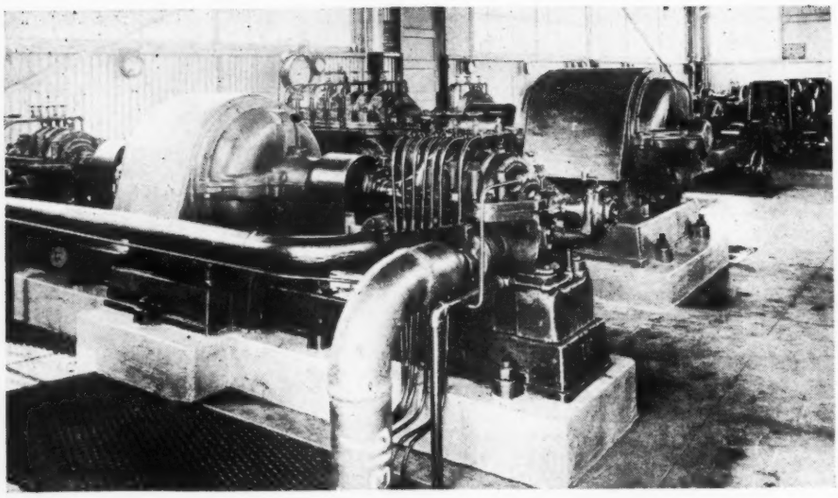
Electric Power purchased from the Texas Power & Light Company is a basic profit-factor in petroleum operations from wells to refineries . . . because of lower installation cost; low operating and maintenance cost; greater efficiency and flexibility; maximum portability; greater salvage value; and less lost time from shut-downs. More than 20 years of experience provides a wealth of facts to prove superiority of *Purchased Electric Power* in the petroleum industry. This Company pioneered in supplying transmission line electric power to the petroleum industry in Texas.

TEXAS POWER & LIGHT COMPANY

Interurban Building . . . Dallas



PROFIT *by using* PURCHASED ELECTRIC POWER



Squirrel-cage induction motors connected to centrifugal pumps, refinery tank-farm pump house

422 operating refineries is 3,749,000 bbl. as shown in Tables 1 and 2, it is significant to note from the U. S. Bureau of Mines report for 1935 that refineries actually processed an average of only 2,750,000 bbl. daily, representing an operating capacity factor of 73 percent. On an annual basis, all the operating refineries processed 966,243,000 bbl., or about the actual total production of crude oil in the United States during 1935.

An examination of refining methods indicates wide variations in the amount of steam produced, boiler pressures, types and amount of fuel burned, use of steam pumps, generation of electric power, purchase of electric power, and the type of distillation and cracking equipment installed. There are 39 different types of cracking units and some eight or ten methods or practices of producing lubricating oils, all of which require different amounts of electric and/or mechanical power and applied heat.

Power Requirements Surveyed

The purpose of the following study was to determine, if possible, the amount of power in its various forms necessary to operate the three classes of refineries. These data should be useful as an indication of the possible applications of purchased power, either in a new refinery being constructed, or in an old refinery to replace steam or internal combustion engine power in its various forms. Detailed information of actual power requirements of 44 representative refineries, or about one-tenth of the total number in operation, was obtained by questionnaires.

The refineries from which answers were received represent slightly more than ten percent of the total number of refineries operating, about 13 percent of the total refinery throughput, and 19 percent of the total electric energy purchased for refining operations in the United States.

The total itemized power requirements for the three types of refineries are shown in Tables 3, 4, and 5, for Class A "Skimming Refineries," Class B "Cracking Refineries," and Class C "Complete Refineries," respectively.

By referring to Tables 3, 4, and 5, it is noted that figures are shown for the weighted average "power requirements," both "electrical and mechanical," the amount of water necessary for condensation of gas vapor, and the steam required for each bbl. of oil charged to stills.

These results are re-tabulated in Table 6 for the three classifications of refineries.

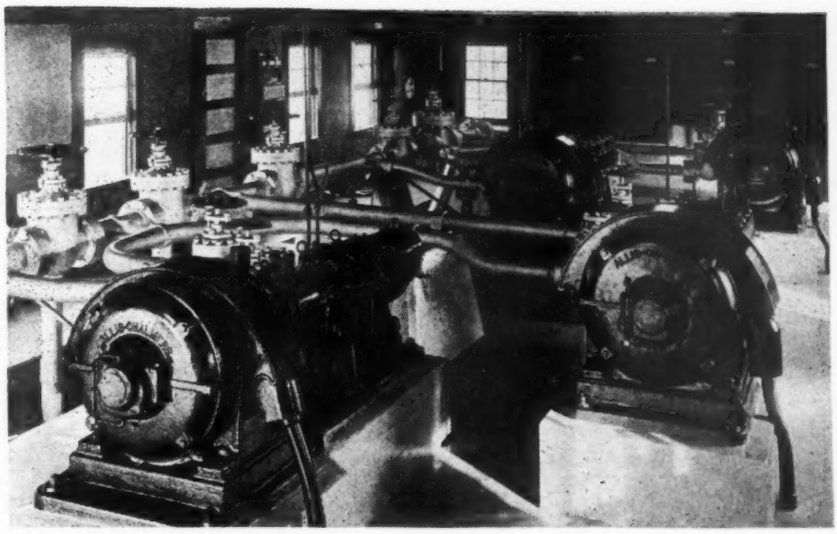
Referring to Table 6 it is noted that the 44 refineries studied operated at 77 percent annual operating capacity. The operating capacity for the active 422 refineries in the United States was slightly less, or 73 percent; possibly accounted for by the smaller use of gasoline in the winter months in the territory of the larger number of the refineries not covered in this study. Virtually all the 44 refineries covered in this study are in Kansas, Oklahoma, Louisiana, and Texas. Attention is called to the gradual increase in amount of energy required as the processing of crude becomes more complicated, in passing from a simple distillation of gasoline (Class A) to the cracking process (Class B), and thence to the manufacture of lubricating oil (Class

TABLE 4

"Cracking" Oil Refineries (Class B). Energy Electrical and Mechanical), Water, and Steam Requirements

Refinery	Rated capacity, bbl./day	Actual annual average throughput, bbl./hr.	Average "Electric Power" requirements, kw-hr./bbl. of crude input				Average "Mechanical Power" requirements, equivalent kw-hr./bbl. of crude input			Total electric and equiv. mech. power, kw-hr./bbl.	Hp. of electric motors/bbl. of hourly throughput	Water requirements			Steam requirements		
			Purchased from utility	Generated in private plant			Gas engine	Oil engine	Steam engines or turbines			Condensing water		Total makeup, gal. per min.	Lb./hr.	Boiler pressure, lb.	Degree superheat
				Gas engine	Oil engine	Steam turbine						Actual, gal. per min.	Bbl. water/bbl. oil				
A	2,000	83	1.68	0	0	0	0	1.8	0	3.48	3.6	1,000	14.5	....	5,000	140	50
B	3,000	83	1.44	0	0	0	2.4	0	.40	4.24	4.9	1,500	21.2	....	18,000	150	0
C	3,000	111	.14	0	0	0	0	1.02	.21	1.37	.9	1,200	13.0	....	10,300	125	0
D	3,000	123	.31	0	0	0	0	0	1.07	1.38	1.4	1,600	16.0	....	12,500	160	0
E	4,000	97	.49	0	0	0	1.55	0	1.34	3.38	2.2	2,000	17.0	100	15,500	120	0
F	4,500	187	1.54	0	0	0	1.00	0	.16	2.70	3.2	4,500	29.0	....	25,000	150	0
G	5,000	142	1.06	0	0	0	2.10	0	.17	3.34	2.9	2,000	16.8	250	16,000	100	0
H	5,000	125	1.77	0	0	0	.80	0	1.04	3.60	4.6	1,350	19.2	....	21,000	100	0
I	6,500	200	.87	0	0	0	1.13	.6	.30	2.90	3.1	5,000	30.0	....	.....	150	0
J	10,000	194	2.06	0.6	0	0	0	0	1.42	3.48	....	10,000	61.5	....	24,000	100	0
K	15,000	375	.72	0	0	0	.55	0	1.07	2.37	3.9	4,500	14.4	500	53,500	150	0
L	15,000	417	1.37	0	0	0	0	0	1.20	2.57	2.2	8,000	23.0	....	29,000	200	0
M	20,000	645	1.32	0	0	0	1.16	0	.54	3.02	....	24,000	44.1	....	88,000	150	0
N	20,000	750	1.86	0	0	0	.92	0	2.50	5.28	4.2	15,000	24.0	....	133,000	160	100
O	25,000	750	2.80	0	0	0	0	0	0	2.80	3.5	13,000	20.8	....	40,000	110	0
P	25,000	920	.69	0	0	0	0	0	1.78	2.47	....	12,500	16.3	....	119,000	140	0
Q	70,000	2,500	1.00	0	0	0	.30	0	1.05	2.35	2.7	35,000	16.8	....	250,000	200	100
17	236,000	7,702††	1.29*	.03*	0	0	.46*	.05*	1.34*	3.17*	3.04*		22.3*	10%	115 lb./bbl.*		

*Weighted average.
††Percent throughput of nominal capacity = 78.5.



A 150-hp., 2300-volt, induction motor for crude charging pumps, multiple pressure

C). This also holds true for the increase of condensing water required in passing from Class A refineries of low-temperature operation to the high-temperature cracking process Class B refineries. The condensing water requirements of Class C refineries are virtually the same as those of Class B refineries, for essentially they both resort to cracking in the same proportions in the production of gasoline. The additional energy required in a Class C refinery, over the Class B refinery, is used principally for refrigeration to remove paraffin wax from the lube stock, and for distillation recharging.

Potential Market for Power Sales

Again from Table 6, note that the weighted average use of purchased electric energy is 1.53 kw-hr. per bbl. of oil processed for the 44 refineries studied, but the average purchases of energy for the entire group of 422 refineries in the United States are only 1.11 kw-hr. per bbl. of oil processed. This discrepancy can be reconciled when consideration is given to the fact that the average age of the 44 refineries studied is perhaps only half that of the 422 refineries. The older refineries (see Table 8) use steam pumps to a great extent; the more modern refineries, such as the 44 studied, have taken advantage of the more recently developed centrifugal pumps that can be driven by motors more advantageously.

Thus, it may be said that the potential market for sales of purchased power in the modernization of the older plants is of the order of 1.53-1.11, or 0.42 kw-hr. for every bbl. of oil being refined. Table 6 indicates a total of 838,343,000 bbl. being processed in refineries during 1935, in the remainder of the 378 refineries not studied. If uneconomic, steam pumps can be replaced, or if uneconomic, generation of mechanical steam power can be replaced—the refinery purchased-power market would absorb approximately 352,000,000 kw-hr. represented by a demand on power utility systems of about 60,000 to 70,000 kw.

The potential market for purchased utility power can be arrived at in another manner by using the U. S. Bureau of Mines data for capacity and operating capacity factor, coupled with information obtained from the survey of 44 refineries covered in this study.

Table 7 is introduced to bear out this conclusion.

Thus, by using one method of analysis to determine the potential market for purchased power from Table 6 the results indicate such sales may approach 352,000,000 kw-hr. per annum; another method as shown by Table 7, indicates a slightly lower value or 339,000,000 kw-hr. annually.

Referring to Table 3, Class A refineries, note that the average amount of purchased power is three-tenths kw-hr. per bbl. of oil throughput. This no doubt represents the actual amount of power required to pump the condensing water of 6.62 bbl of water per bbl. of oil processed through the condensing coils and cooling tower against an average head of 70 lb. per sq. in., leaving the use of purchased power for other operations practically nil. This situation is also true regarding the water pumping load in cracking refineries (Class B) shown in Table 4, where the total average use of purchased power is 1.29 kw-hr. per bbl. of oil processed. Water pumped in the amount of 22.3 bbl. of water per bbl. of oil will require approximately nine-tenths kw-hr. of energy, leaving only four-tenths kw-hr. as an average for other purposes throughout the refinery.

Conversely, those refineries using an excess amount of condensing water should be investigated with the idea of reducing the power purchased as in

TABLE 5

"Complete" Oil Refineries (Class C). Energy (Electrical and Mechanical), Water, and Steam Requirements

Refinery	Rated capacity, bbl./day	Actual annual average throughput bbl./hr.	Average "Electric Power" requirements, kw-hr./bbl. of crude input				Average "Mechanical Power" requirements, equivalent kw-hr./bbl. of crude input			Total electric and equiv. mech. power, kw-hr./bbl.	Hp. of electric motors/bbl. of hourly throughput	Water requirements			Steam requirements		
			Purchased from utility	Generated in private plant			Gas engine	Oil engine	Steam engines or turbines			Condensing water		Total makeup, gal. per min.	Lb./hr.	Boiler pressure, lb.	Degree superheat
				Gas engine	Oil engine	Steam turbine						Actual, gal. per min.	Bbl. water/bbl. oil				
A	5,000	166	5.30	0	0	0	0	0	1.35	6.65	6.6	.....	.....	.....	50,000	150	0
B	5,000	141	4.95	0	0	0	0	0	1.59	6.54	.....	2,500	21.2	.....	54,000	165	0
C	5,000	166	1.67	0	0	0	0	0	4.20	5.87	3.9	3,000	21.4	.....	80,000	140	0
D	8,000	217	1.48	0	0	1.05	0	0	3.70	6.20	.....	3,500	19.5	.....	80,000	140	30
E	10,000	417	2.52	0	0	0	.86	0	1.91	5.25	5.9	5,000	14.5	600	110,000	140	0
F	12,000	400	.63	0	0	4.55	0	0	.75	5.93	.....	.....	.....	.....	210,000	175	115
G	12,000	417	2.65	0	0	0	0	0	2.88	5.53	6.3	8,000	23.2	1,000	75,000	140	0
H	16,000	585	1.20	0	2.22	.51	1.37	0	.26	5.57	5.6	9,000	18.5	1,200	85,000	125	0
I	30,000	833	1.68	0	0	2.65	.54	0	.54	5.40	6.6	20,000	28.6	2,000	200,000	150	0
J	50,000	1,660	3.00	0	0	0	1.12	0	1.35	5.47	6.0	40,000	28.6	3,000	300,000	125	100
10	153,000	5,002††	2.34*	0	.25*	.90*	.69*	0	1.42*	5.55*	6.0*		24.5*	9.5%	250 lb./bbl.*		

†50-gal. bbl.
*Weighted average.
††Percent throughput of nominal capacity = 79.0.

TABLE 6

Weighted Average Power, Water, and Steam Required

Class	Number of refineries studied	Total throughput, bbl./hr.	Percent throughput of nominal capacity	Total bbl. throughput 1935	Weighted average kw-hr. purchased per bbl. oil	Total purch. electric power, kw-hr.	Weighted average bbl.† water/ bbl. oil	Weighted average lb. steam/ bbl. oil
A	17	1,864	69	16,300,000	0.30	4,890,000	6.6	78
B	17	7,702	78	67,600,000	1.29	87,200,000	22.3	115
C	10	5,002	79	44,000,000	2.34	103,000,000	24.5	250
Total.....	44	.....	77	127,900,000	1.53*	195,090,000	.....	.....
1935 total for U.S.A.	422	.....	73	966,243,000	1.11*	1,071,841,000	.....	.....

*Weighted average.
†50 gal. bbl.

TABLE 7

Determination of Potential Market for Purchased Power

Class of refinery	Capacity in bbl. per day (U.S. Bureau of Mines, 1935)	Actual throughput bbl./day (U.S. Bureau of Mines) 73 percent operating capacity factor	Percent of total oil refined	Purchased energy required (reference Table 6) kw-hr./bbl.	Purchased electric energy potential market, provided 422 refineries were electrified similar to the 44 studied, total kw-hr.
A	1,519,540	1,115,000	40.5	0.3	122,000,000
B	392,800	289,000	10.5	1.29	136,000,000
C	1,837,495	1,350,000	49.0	2.34	1,153,000,000
	3,749,835	2,754,000	100.0		1,411,000,000
Less sales of purchased electric energy in 1935					1,071,841,000
Additional possible sales of electric energy					339,159,000

"C" and "J" in Table 3, "J" and "M" in Table 4, and "J" in Table 5.

An ideal operation, wherein the total "Electric and Mechanical" power requirements are purchased, is disclosed in Table 4, Refinery "O," using 2.8 kw-hr. per bbl. of oil processed, and generating only 53 lb. of steam per bbl. of oil processed. It should follow that if one refinery can be operated wholly on purchased power and minimum amount of steam, others could do the same, thereby greatly increasing the potential market for purchased power. Other refineries approaching this ideal operating situation are "A" and "B" (Class C) shown in Table 5, both of which purchase approximately 80 percent of their total power requirements, with an average amount of steam generated.

Initial Power Applications

A further study of Tables 3, 4, and 5, discloses an appreciable amount of "electric or mechanical power" actually generated by use of internal-combustion engines, and steam engines, leading to the conclusion that power applications best adapted for conversion to purchased electric power would be those in which the present electric power used is being generated by the use of steam and internal combustion engines.

Electric Power Represents 44 Percent of All Power

The present amount of electric power being generated by steam power is principally in the "complete" (Class C) refinery, and amounts to about 440,000,000 kw-hr. annually, and the amount of energy generated by internal combustion engines is 126,665,000 kw-hr., or a total of 566,665,000 kw-hr. that are generated in private plants in refineries throughout the United States. It may thus be said that oil refineries use a total of 1,638,506,000 kw-hr. (1,071,841,000 kw-hr. purchased plus 566,665,000 kw-hr. generated) which in turn is 44 percent of the total "electric and mechanical" power required in all operating refineries.

Economic Value of Fuels Used in Private Generating Plants

No doubt, a considerable portion, if not the greater portion, of the 440,000,000 kw-hr. generated privately with steam, is generated with bleeder or extraction turbines and, therefore, the cost of fuel used, or the market value of the fuel used, enters into the economic determination of the amount of electric energy that can be successfully and cheaply produced.

By referring to Table 8, a great many conclusions can be drawn regarding the economic values of fuels consumed.

In the case of "East Coast" refineries, note that they consume a preponderance of oil as fuel, 58.8 percent, due to not having cheap natural gas available, as is the case with the "Arkansas-Louisiana Inland," "Rocky Mountain," and "California" refineries.

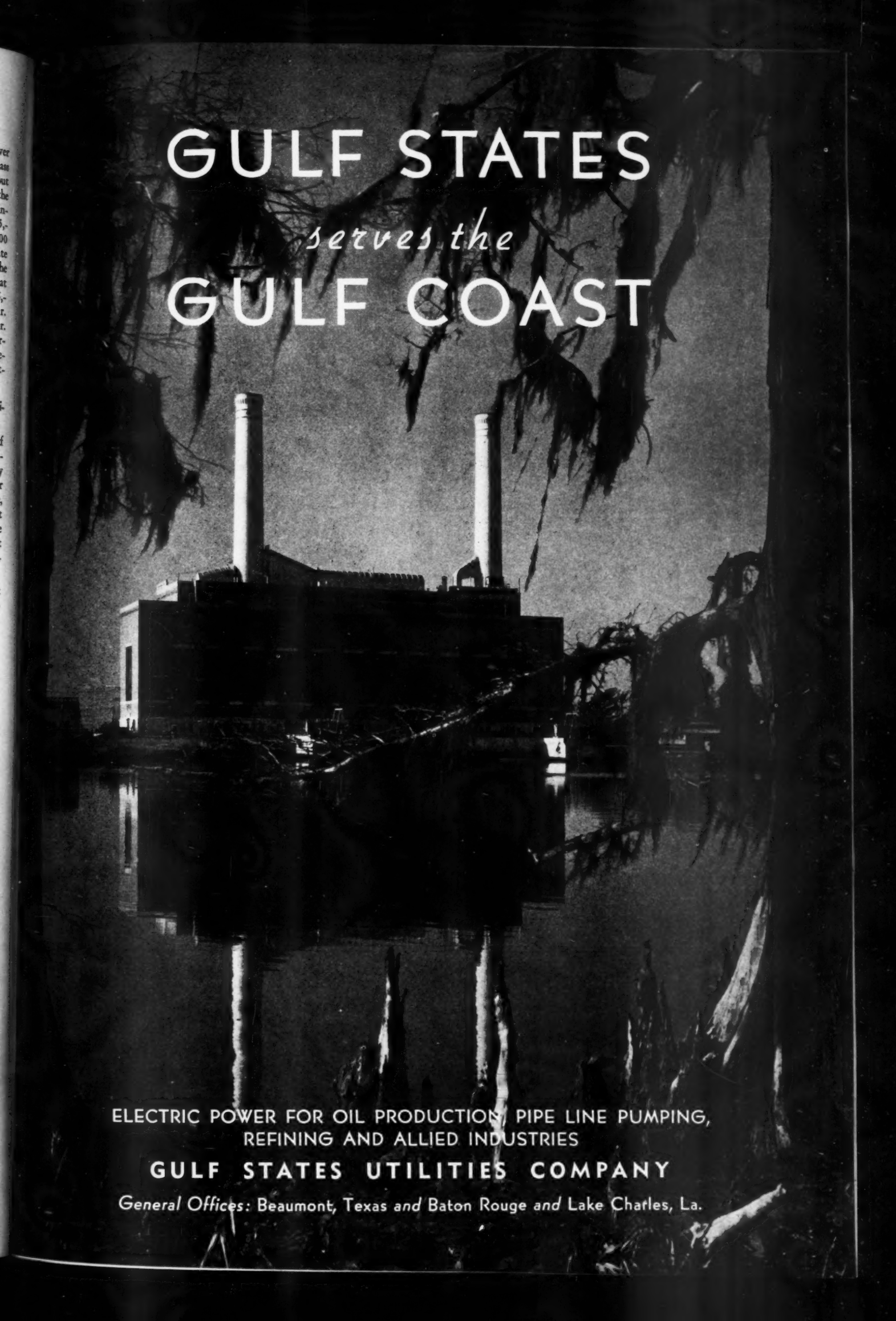
In the case of "Appalachian" refineries, note the great amount of coal (40 percent) used as basic fuel. However, their B.t.u. total input (1,119,000 per bbl.) is greater than any other district, leading to the conclusion that coal is cheap, and that their "cracking" facilities are not of recent installation as disclosed by the data showing

TABLE 8

Percent Various Types of Fuels Consumed in 422 Operating Refineries During 1935 by Districts (Based on U. S. Bureau of Mines Data Submitted for 1935)

Fuels	Average heat content, B.t.u. per unit	East Coast	Appalachian	Indiana, Illinois, Kentucky	Oklahoma, Kansas, Missouri	Texas, Inland	Texas Gulf	Louisiana Gulf	Arkansas, Louisiana, Inland	Rocky Mountain	California	Average of 422 refineries
Oil	6,000,000/bbl.	58.80	22.15	27.60	34.59	37.00	18.30	12.50	11.30	22.60	27.00	31.40
Acid sludge	4,500,000/bbl.	5.40	.25	2.39	7.74	.95	3.71	.10	.10	3.30	5.05	3.94
Coal	13,000/lb.	1.20	40.00	14.10	.04	0	0	0	0	1.50	0	5.35
Natural gas	1050/cu. ft.	0	10.10	.19	16.30	22.80	16.05	25.90	52.00	32.60	34.80	14.15
Still gas	1400/cu. ft.	33.60	26.20	54.43	39.60	38.60	60.50	57.10	36.20	38.00	32.30	43.00
Coke	15,000/lb.	.40	.62	.86	1.11	0	1.18	2.30	0	.90	0	.58
Purchased steam	1000/lb.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.96
Purchased power, kw-hr.	3415/kw-hr.	.60	.68	.43	.62	.65	.26	2.10	.40	1.00	1.00	.62
Total		100.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	100.00
Purchased power, kw-hr. per bbl.		1.16	2.22	.88	1.23	1.08	.45	2.46	.80	2.51	1.22	1.11
Thousands of bbl. refined		170,277	38,454	129,958	107,752	61,694	200,799	43,015	17,416	19,029	177,849	966,243*
Thousands B.t.u. of fuel consumed per bbl.		671	1,119	697	660	563	588	514	564	840	419	615

*Total


GULF STATES
serves the
GULF COAST
ELECTRIC POWER FOR OIL PRODUCTION, PIPE LINE PUMPING,
REFINING AND ALLIED INDUSTRIES
GULF STATES UTILITIES COMPANY
General Offices: Beaumont, Texas and Baton Rouge and Lake Charles, La.

the lowest percentage of refinery gases recovered and used for fuel in any of the districts.

In reviewing the percentages of fuel consumed, "the average for all refineries" in Table 8, of the non-marketable fuels, acid sludge, refinery gas (methane and ethane), and coke, comprises a total of 47.52 percent of the total fuel required for all purposes of 615,000 B.t.u. per bbl.

Thus, with 47.52 percent of 615,000 B.t.u. or 292,000 B.t.u. of heat value available that can not be sold on the market, and an average of 173 lb. of steam being produced for each bbl. of crude refined, requiring perhaps 1600 B.t.u. per lb. of steam to be fired under the boilers, it is obvious that an almost perfect heat balance could be attained between the actual amount of steam produced and the amount of waste or non-marketable fuels available for boiler firing.

From Table 8 it is noted that use of acid sludge amounts to 7.74 percent of the total fuel required in "Kansas, Oklahoma, Missouri" district. If the solvent process for lubricating-oil refining or the cuprous chloride process is adopted generally throughout this district, and assuming the acid-sludge percentage were reduced to the national average of 3.94 percent or almost one-half of the present amount being produced, it is estimated that an additional 40,000,000 kw-hr. could be sold to replace steam power.

It is also noticeable that the use of petroleum coke does not appear to be very great, the average for the entire country being only 0.58 percent, or about one-half of one percent of the total fuel consumed. The amount of coke produced, however, is not disclosed, and it is generally understood that the fuel market will absorb the production at a higher price than other waste fuels or gases. Its production is gradually becoming less each year because of increased efficiency in newer installations of cracking processes.

Detailed Analysis of Fuel Costs of Individual Plants Desirable

General conclusions, as determined from average results mentioned herein, cannot be construed as applying to all individual refineries, for no doubt there are certain refineries that do not purchase any electric power at all. Hence, a more detailed analysis of the individual refinery's fuel costs is necessary to promote the use of purchased electric power.

In further study of Table 8, promotional sales efforts might be suggested for those districts showing a low average amount of purchased electric power usage, as "Indiana and Kentucky," "Texas Gulf," and "Arkansas-Louisiana Inland."

The value of data shown in Table 8 is further increased, when, using as an example, in the refineries in the "East Coast" district it is shown that they obtain 58.8 percent of their total fuel requirements from fuel or distillate oils. The market value of distillate fuel oil may increase to such values that its use for generating steam, and in turn power, would prove more costly than an outright purchase of electric power for the same operation. The same may be said for the refineries in the "Appalachian" district, obtaining 40 percent of their total heat energy from coal.

No doubt the 1,119,000 B.t.u. required for refineries in the "Appalachian" district per bbl. of oil refined can be attributed to poor boiler combustion, obsolete cracking furnaces and stills, which contribute to this economic waste of fuels. Electric motors using purchased power may be cheaper to operate than boilers producing steam for power purposes.

Further Fields for Exploration

The possibility of electric utilities in large industrial centers installing extraction or bleeder turbines adjacent to refineries and selling both steam and electric energy appears to deserve consideration, particularly in the "East Coast," "Appalachian," and "Illinois" districts, provided such power companies desire additional capacity, and provided the market would absorb the fuel oil for heating or marine usage at a higher price than ordinarily obtains.

If the use of the polymerization process continues to increase and refinery gases in greater quantity are used as charging stock, the refiner may be forced to look elsewhere for power energy and purchased power may prove most economical.

On the assumption that about 20 percent of the present refinery gases can be recovered further by the polymerization process, a further market for about 75,000,000 kw-hr. is potentially possible to replace the present power generated by steam from these gases, and after allowing for increased power required for higher compression and condensing water necessary.

Principal uses of electrical power in refineries

1. Lighting

   It is generally considered good practice to use about three percent of the total energy required in refining operations for floodlighting, tank lighting, building lighting, etc.

2. Pumping

   (a) Water pumping through condensers requires pressures of about 50 lb. per sq. in.
   (b) Water pumping through spray ponds requires pressures of about 20 lb. per sq. in.
   (c) Charging pumps for both crude and hot oil. In the case of charging pumps for cracking units, the hot oil is recirculated perhaps eight or ten times and pressures of 1000 lb. are required. Continuity of power supply is essential, and steam turbines can be used for speed control in starting and stopping, or to obtain better heat balance.
   (d) Charging pumps for reflux, tars, pitch, and other side products from fractionating columns.
   (e) Transfer pumps and treating pumps.
   (f) Boiler-feed pumps.
   (g) Deep-well pumps for make-up.

3. Compressors

   (a) Air compressors for maintenance work, agitating air, tube cleaning, tank and car cleaning.
   (b) Ammonia compressors for refrigeration to eliminate paraffin from lubricating oil, and synchronous motors for better power factor throughout the refinery, are usually installed.

4. Welding

   All maintenance, construction, and repair work requires arc-welding, and portable motor-driven generators are essential.

5. Machine Shop

   Lathes, drills, pipe-threading machines, hacksaws, grinders, buffers, cranes, planers, and many other applications requiring individual motor drive, are essential in every refinery.

6. Conveying Equipment

   In large refineries, particularly those in which lubricating oil is produced, motors are used to convey sacks, drums, cans, and cartons of the finished product. Also, chain and belt conveyors are adapted to move filtration clays, acid-sludge, and petroleum coke.

7. Miscellaneous

   Small motors are adaptable to the following uses:
   (a) Mechanical agitators
   (b) Mechanical mixers
   (c) Oil dehydrators
   (d) Clocks and meters
   (e) Hoists and trucks

P 516.9
P 615.511

Arkansas Fuel Oil Company refinery, Shreveport, Louisiana

Electric Power in East Texas and Rodessa Fields

PETROLEUM ENGINEER EXCLUSIVE FEATURE

Proration of production has prompted combination billing for scattered meters—demand rate permits low unit cost on high load factor operation

By J. E. ELLIOTT

Industrial Engineer, Southwestern Gas and Electric Company

ELECTRIC power has been an important factor in the development of the East Texas and Rodessa oil fields. Service is supplied for pipe-line pumping, oil-well pumping, refineries, water-pumping, gathering stations, camp-lighting, machine shops, and miscellaneous operations. These areas are supplied with service by the Southwestern Gas and Electric Company.

Shortly after the discovery of these fields, the company constructed a network of transmission and distribution lines to serve them, interconnected to supply continuity of service, a feature of foremost importance in oil-field operations.

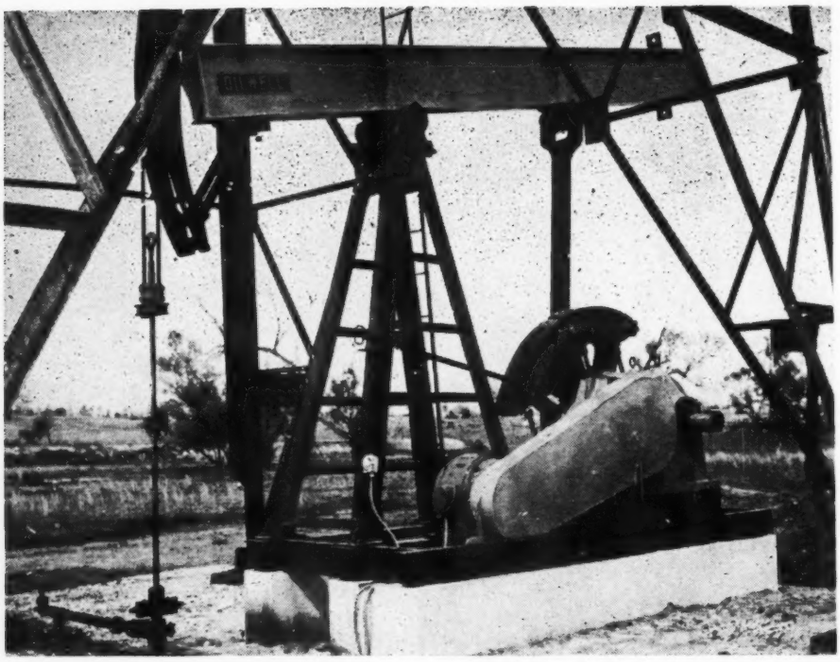
There is available a total capacity of 125,000 hp. in power plants and interconnected facilities to supply these fields. This capacity is sufficient for present and probable future requirements of the field.

Electric rate schedules were designed to meet the peculiar characteristics of oil field power loads. Most operations in the oil industry have inherently high load factors and the power bill should reflect the resulting benefits. The demand type of rate is particularly adapted to oil operations because it results in a low unit cost for service to loads operating at high load factors. For an oil company unable to operate at a high load factor, there is available a rate, without a demand charge, based solely on the amount of energy used. As the East Texas and Rodessa fields are producing under drastic proration, the company has instituted the maximum simultaneous demand method of billing to meet this operating condition.

If the customer so desires, the company will supply all transformation equipment of standard voltage and each electric service location will be billed separately. If an oil company owns and maintains the transmission and distribution lines on the various

J. E. ELLIOTT

was born in Corsicana, Texas—Was associated with the Texas Power & Light Company during the electrification of the Mexia and Powell fields—Attended Rice Institute, Houston, Texas, after which he took a post-graduate course with the Westinghouse Electric and Manufacturing Company, Pittsburgh, Pennsylvania, and subsequently was employed in the company's design engineering department—Resigned from Westinghouse in 1925 to become associated with the Southwestern Gas and Electric Company, which company he has served in various capacities for the last 14 years, now being manager of the industrial engineering department — His principal interest is in the application of electric power to the various branches of the petroleum industry—Is a director and past-president of the Petroleum Electric Power Association.



Oil well being pumped by an electric motor

leases, the company will set any required number of meters to measure the energy delivered to each lease and the energy used on the various leases will be added together to appear on only one statement. This is equivalent to having all the energy pass through a single meter, although the leases may be scattered over a wide area.

Our experience would lead us to believe that oil companies do not always give proper thought to many items of operating costs included in the electric power bill. When another form of power is used, it is likely that the operating costs will be distributed to several different accounts and, unless they are especially compiled, a true picture of the operating cost may not be obtained.

Well-Pumping

The East Texas oil field includes an area of 130,000 acres and has approximately 26,000 producing wells. There are in excess of 6000 wells equipped for pumping by various methods of artificial lift. Gas-lift is used rather extensively, but it is not known at present whether this method may be used successfully to produce the wells throughout their economic life.

Several central powers have been installed, especially on the east side of the field in areas where water encroachment is not anticipated in the immediate future. The central-power method of pumping provides a low lifting cost, and it is particularly adapted to settled production. It does not permit pumping of large volumes of fluid and thus lacks the flexibility that can be obtained with individual pumping units.

Individual gear-driven pumping units have received wide acceptance by oil operators for well-pumping. Besides being particularly adapted to electric-motor drive, the individual unit provides flexibility, has a low maintenance cost and high overall efficiency.

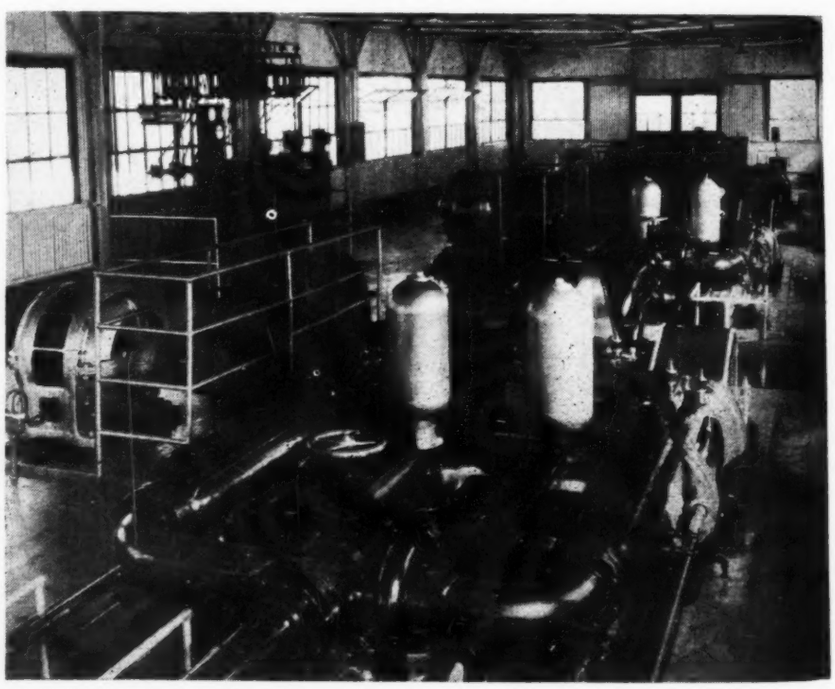
At the time the electric motor was first used in the production of oil, the two principal phases of well operation, pumping and servicing, were provided for in a single standard rig. This practice of equipping a well for both pumping and servicing is rapidly disappearing. It is now general practice to perform the well-servicing operation with portable equipment.

Electric motors are now available for the pumping operation only, having a considerably lower first cost and higher efficiency than oil-well motors required formerly to power both pumping and servicing operations. The pumping operation is now powered usually by a squirrel-cage induction motor, either open or weatherproof type, having various modifications as follows:

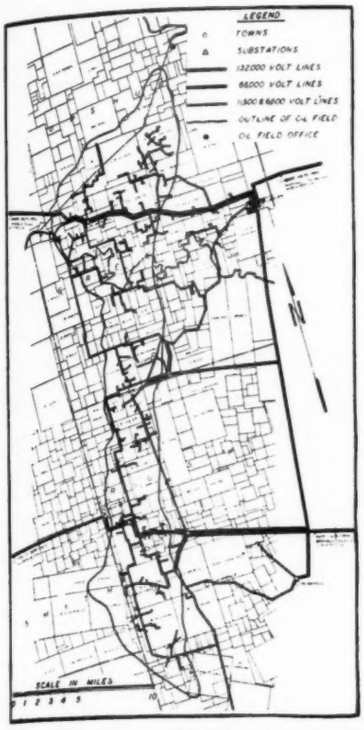
1. Single-rated, single-speed, normal torque.
2. Single-rated, single-speed, high torque.
3. Star-Delta, double-rated, single-speed.
4. Double-rated, two-speed, constant torque.
5. Triple-rated, single-speed.

Recent developments in motors for oil-well pumping are specially designed to obtain high-slip operation. It provides a cushion-effect that tends to absorb electrically the mechanical shock of fluctuating loads instead of permitting this shock to be transmitted to the machinery.

The daily allowable in the East Texas field of approximately 20 bbl. per well permits the allowable production to be obtained usually in two or three



Interior of pipe-line station in Rodessa field, Louisiana



Map of East Texas field showing transmission lines and electrical substations

hours' pumping-time. Several companies have effected a considerable saving in labor costs by installing time-clocks to start and stop the wells at a predetermined time interval. The time-clock method of operation has enabled the companies to keep their demand at a minimum, resulting in a higher operating load factor, and a lower unit cost for energy. Wells on the east side of the field producing a relatively small amount of fluid are being operated successfully with time-switches on intermittent service, thus effecting a saving in power, labor, and maintenance costs.

Owing to the uncertainties of proration and water-encroachment, many operators have equipped individual pumping units with backside-cranks to which pull-rods may be attached in order to power additional wells pumped by jacks. A pitman connection has also been devised whereby one or two additional wells may be pumped without using a backside-crank.

On the west side of the field, where water is encountered, heavier equipment, including larger motors, is required as compared with units on the east side, or near the center of the field where there is little or no water. Motors on individual pumping installations range in size from 5 to 25 hp. When it is desired to install a single-rated motor, it is estimated that 15 hp. is ample to provide for present and future requirements. In the multiple-well hook-up, which is quite popular, the motor-size should normally be increased to provide for the additional load. One three-well installation on the east side of the field is being powered by a 10-hp. motor having an actual input of 7½ hp.

The total actual energy required to pump a given number of bbl. from any depth remains virtually constant, regardless of the elapsed time in which the operation is performed. It will take a 5-hp. motor twice as long to perform the same operation as a 10-hp. motor. When service is purchased under a demand rate, it is to the operator's advantage to keep the horsepower demand at a minimum to obtain the lowest possible cost for energy.

The electric-power cost to pump 20 bbl. of oil from an East Texas well for a 24-hr. period would be less than were the same production pumped in one or two hours. In order to determine the length of pumping time that will be most economical, it is necessary to balance the increased labor cost against decreased energy cost.

A bbl. of East Texas crude oil weighs approximately 300 lb. The number of ft-lb. required to lift a volume of one bbl. from a depth of 3600 ft. may be calculated as follows:

$$300 \text{ lb.} \times 3600 \text{ ft.} = 1{,}080{,}000 \text{ ft-lb.}$$
$$1 \text{ kw-hr.} = 2{,}654{,}000 \text{ ft-lb.}$$

Energy required to lift one bbl. of oil 3600 ft.

$$= \frac{1{,}080{,}000}{2{,}654{,}000} = .407 \text{ kw-hr.}$$

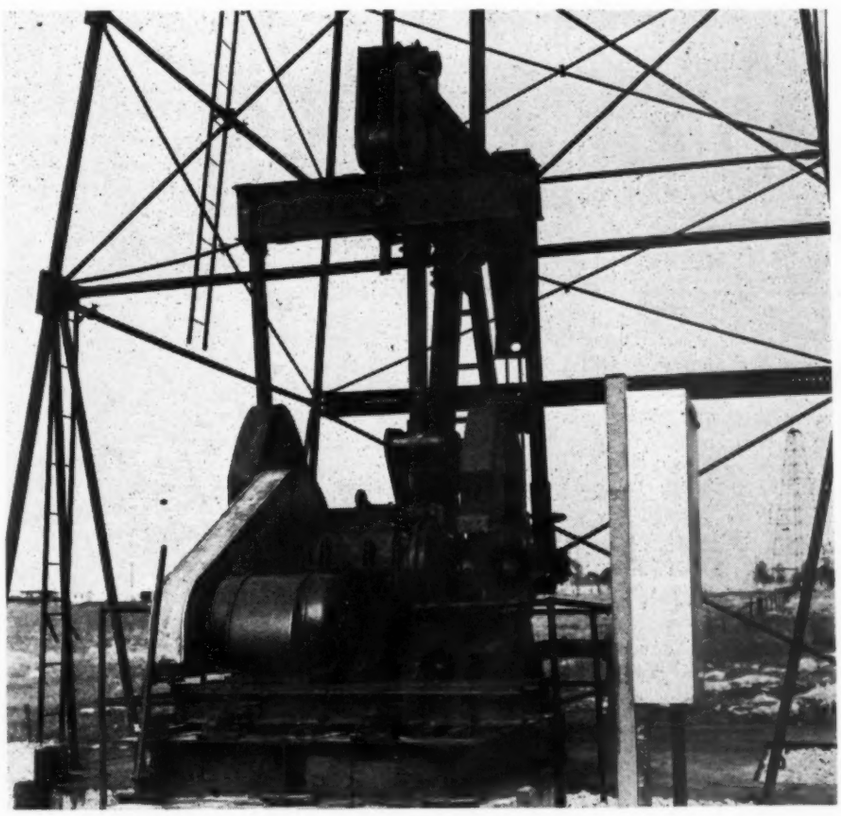
This calculation is based on 100 percent overall efficiency and does not take into consideration influencing factors such as gas in solution that would tend to decrease the amount of work required. In performing this work mechanically, the actual power input will depend upon the value of the overall efficiency. Assuming an overall efficiency of 50 percent, 488 kw-hr. will be required per month to pump 20 bbl. per day, or 600 bbl. per month from a depth of 3600 ft.

$$\frac{20 \times 30 \times .407}{.50} = 488 \text{ kw-hr. per mo.}$$

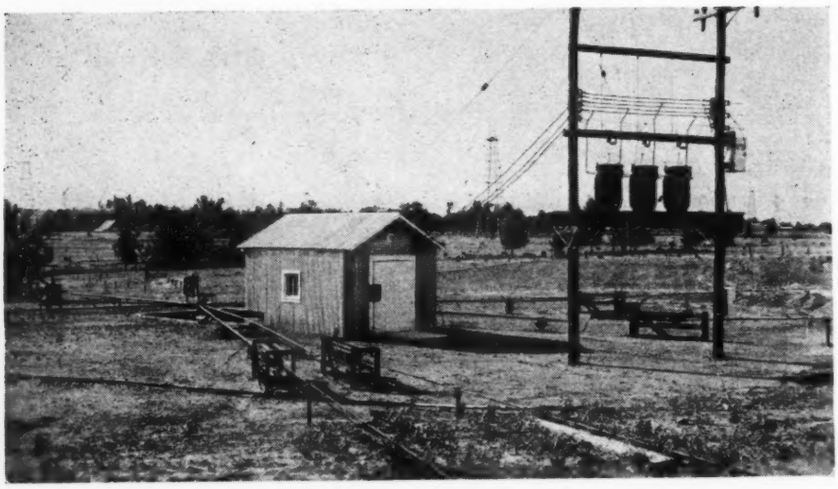
The following table shows the estimated cost of electric power required to pump an East Texas well producing 20 bbl. of pipe-line oil (no water) from a depth of 3600 ft. at various unit costs per kw-hr. The rate earned is dependent upon the load factor and the number of kw-hr. purchased.

Electric Power Cost per Month

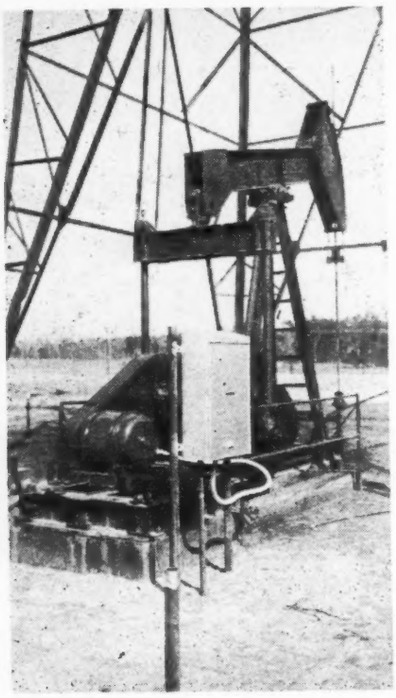
Kw-hr.	*Rate, cents per kw-hr.*				
	1.5	1.25	1.0	0.9	0.8
488	$7.32	$6.10	$4.88	$4.39	$3.90



A hook-up for pumping an oil well with a motor and purchased electric power



A 100-hp. motor in this central power pumps ten wells



An East Texas well being pumped by a 15-hp., 440-volt motor

Survey	Lease	Power required, kw-hr. per mo.
Ximines	Holland	40
Sanches	Willingham	40
Penida	May Mattox	80
Johnson	Pritchard	80
Van Winkle	Knowles	110
Van Winkle	Knowles	130
Van Winkle	I. & G. N.	170
Van Winkle	Alexander	180
King	Burrough	240
Castleberry	Hampton	240
Van Winkle	Reynolds	250
Van Winkle	I. & G. N.	270
Clark	Holt	280
Smith	Neal	290
Van Winkle	Knowles	310
Van Winkle	Peterson	350
Clark	Wells	370
Hobson	Wells	370
Parker	Alford	430
Van Winkle	Hughey	510

Past experience has caused many companies to doubt the economies of purchased electric power for oil-well pumping when large volumes of salt water are encountered. Any basis for this objection has been eliminated by the Southwestern Gas and Electric Company in the rates it has designed for oil-field service. In these rates, the unit cost continues to decline as the load increases. In other words, when large volumes of salt water are pumped, the power requirements will be greater, of course; but when more power is used, the average rate is lowered.

There are relatively few pumping installations in the Rodessa oil field. Because of the depth of the producing area, it is quite possible that bottom-hole centrifugal pumps will be used extensively when pumping becomes necessary.

Pipe Lines

More electric power is being used in the East Texas and Rodessa fields for pipe-line pumping than for oil-well pumping; principally because wells producing by artificial lift require a relatively small amount of energy.

Electric service is supplied to 80 percent of the main trunk-line stations that are situated within the confines of the East Texas oil field. These stations purchase annually approximately 75,000,000 kw-hr. of energy. The owners of a number of intermediate booster stations also purchase their power requirements. Purchased electric power is supplied to more than 500 gathering stations situated in various parts of the field.

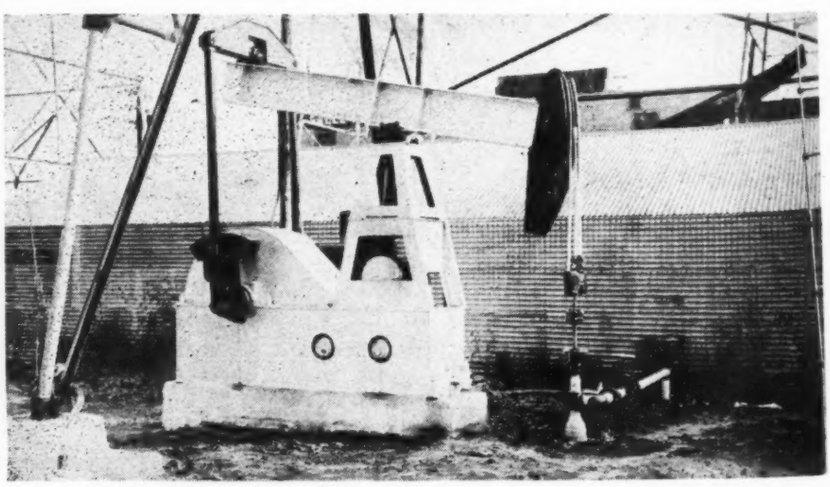
A large percentage of the oil produced in the Rodessa field is being transported through pipe-line stations utilizing purchased electric power.

Refining

The Southwestern Gas and Electric Company supplies six large and several small refineries with electric service. Electric power is utilized principally for operating compressors, water-pumps, hot-oil charging and transfer pumps, and numerous miscellaneous applications.

It should be noted that the cost per month for pumping will increase in the event it is necessary to pump an appreciable amount of salt water to obtain the allowable.

The energy necessary to produce the monthly allowable for each of 20 wells pumped by motor-driven individual pumping units in various sections of the field is shown below. The wells in which relatively small amounts of energy are required to produce the allowable are being either agitated by gas in solution or pumped from a high fluid level.



Kilgore Refining Company No. 1 Terry, East Texas field

P 516.9
P 615.511

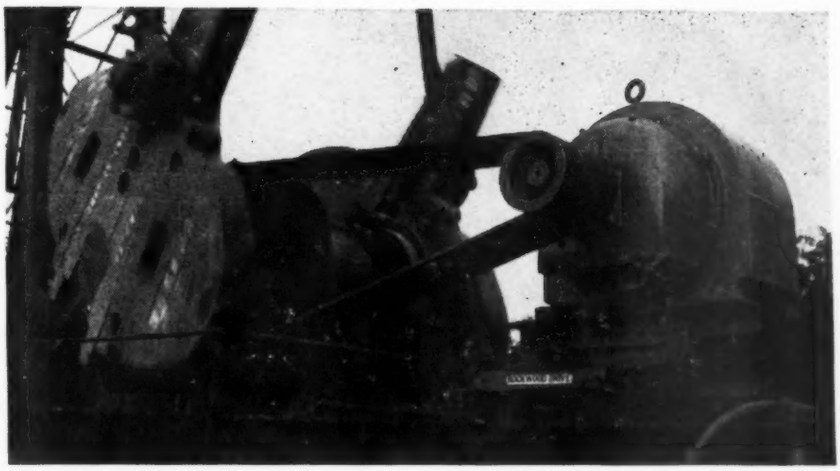


Fig. 1. A 60-hp., high-slip, splashproof oil-field motor operating a pumping unit lifting oil from a depth of 2200 ft.

Purchased Electric Power in Oil Operations in Arkansas

A total load of 10,000 hp. is distributed in oil-well and pipe-line pumping and in refinery operation

By KENNETH C. JOHNSON
Arkansas Power and Light Company

PURCHASED electric power for oil-well pumping, pipe-line pumping, and oil-refining operations has been satisfactorily demonstrated in the oil areas of Arkansas. The oil industry is steadily increasing its use of interconnected highline power service in its many and varied operations. At the present time the oil industry in Arkansas is utilizing about 10,000 hp. in purchased electric power service and is taking advantage of the many benefits and savings that are inherent only with central station power. Among these advantages are: (1) a low installation, operating, and maintenance cost; (2) provides the exact amount of power needed at all times; (3) extremely efficient in all kinds of weather; (4) low fixed charges, such as taxes, interest, insurance, depreciation, etc.; (5) minimum trouble, few repairs, smooth operation; (6) easy to convey from one location to another, and (7) high salvage value.

Formerly, the various oil companies used two-speed, double-rated oil-field motors for well pumping, these motors being 15/35 hp. and 25/65 hp. The low side was used for pumping and the high side for pulling the sucker rods. The trend now, however, is to use single-rated, high-slip, splashproof motors for this operation. The high-slip effect is obtained by increasing the resistance in the rotor. This forms a "cushion" for the up- and down-strokes and increases the effect of the counterbalance on the pumping unit. This high-slip motor has a higher efficiency on this particular type load than the conventional type normal slip motor. The motor being splashproof, the equipment is installed in the open and requires no housing. Among the advantages of the high-slip motor are:

(1) Greater starting torque, eliminating the necessity of rocking the beam when starting a heavy well.

(2) Less starting current required from the line, thus causing fewer local disturbances on the system. The danger of opening the line starters on neighboring wells is materially reduced. Lighter secondary lines may be used.

(3) Cause less disturbance on the system as a whole during starting operations. This is an item of major importance on a system of limited capacity.

(4) Current pulsations resulting from a group of wells being synchronized are less pronounced, hence better voltage regulations may be maintained on the system.

(5) Measured demand on a group of wells is small. This is advantageous to purchasers of electrical energy under a rate specifying that the demand shall be measured.

(6) Probable saving in power due to greater efficiency of the motor.

KENNETH C. JOHNSON

is a graduate in electrical engineering from Mississippi State College, Starkville, Mississippi, 1933—That same year he joined the industrial sales staff of the Arkansas Power and Light Company and was placed in charge of that department in 1935—Is a member and director of the Petroleum Electric Power Club, and has been particularly active in increasing electrification of the oil fields in Arkansas.

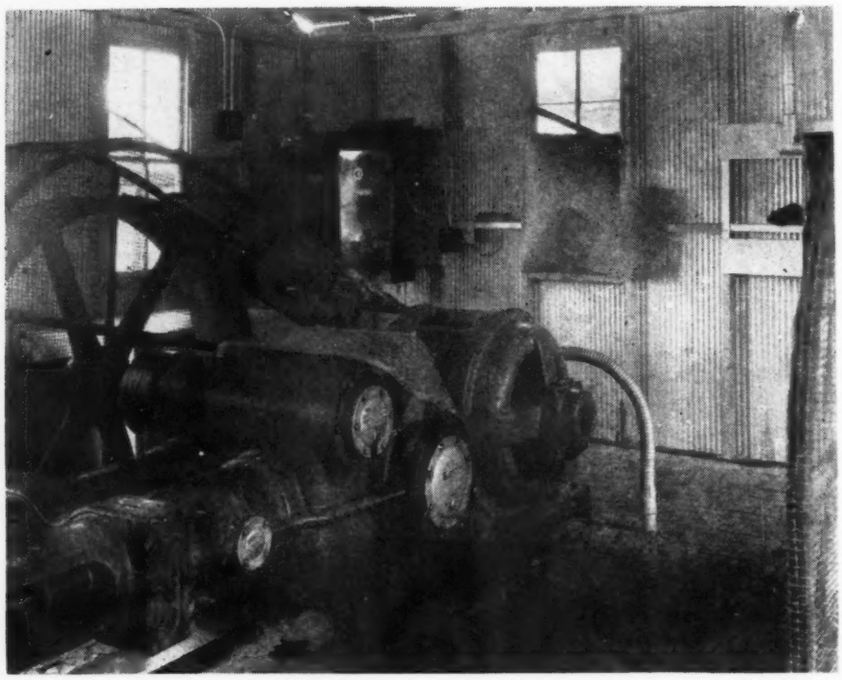


Fig. 2. A 100-hp. motor driving a pipe-line pump

(7) Low stator temperature on equivalent average load.

(8) Adaptable to time switches by reason of great starting torque.

(9) Motors provide a soft drive, thus making it easy on both surface and subsurface equipment, including belts, gears, and sucker rods, and resulting in low maintenance cost.

Fig. 1 shows a 60-hp. high-slip, splashproof oil-field motor operating a pumping unit that is lifting oil from a depth of 2200 ft.

The electrically-driven centrifugal pump, the motor and pump being suspended on the tubing and submerged in the well and power being transmitted to the motor by means of a cable, will probably be used to advantage in the recovery of oil from deep wells in South Arkansas. This equipment has numerous qualifications that lend themselves to the problem of modern deep-well pumping. Purchased electric power fits into the picture in providing a reliable, efficient, and economical source of power for this operation.

The number of oil companies in South Arkansas that have installed electric motors on their trunk pipe-line pumps and on their gathering pumps in recent months has increased.

Fig. 2 shows a 100-hp. motor connected to a pipe-line pump. This equipment pumps as much as 17,000 bbl. of oil per day through an 18-in. line extending 12 miles.

The use of electric power in oil-refining operations in Arkansas is increasing. Electrical equipment in new installations is finding wider application, especially in the operation of new integrated units. Refineries are working toward decentralization of the outlying points of the refinery, such as loading stations, tank farms, and water pumping units, and are aided by the availablity of electric power.

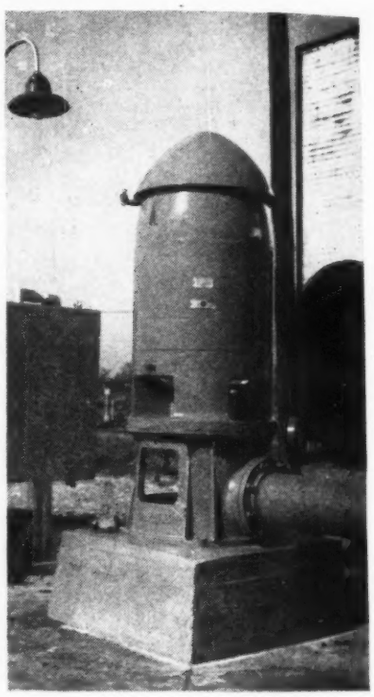
An important factor in the increased adoption of electrical motors in refineries is the action of equipment manufacturers in perfecting safe and reliable motors and auxiliary equipment.

Fig. 3 shows a 100-hp., direct-connected weatherproof motor providing water for the operation of a refinery still.

Fig. 4 shows a 100-hp. motor operating an air compressor station in the Schuler oil field.

In summation it may be said that the use of purchased electric power because of its flexibility is increasing in oil-field operations. The value of this service is realized to a greater extent by the operators who make a more complete use and wider application of this source of power. It is a convenient source of energy for the operation of auxiliaries and associated apparatus, whose value is high and whose benefits may be obtained at a relatively low cost.

Fig. 3. A 100-hp. motor used to pump water to a refinery still



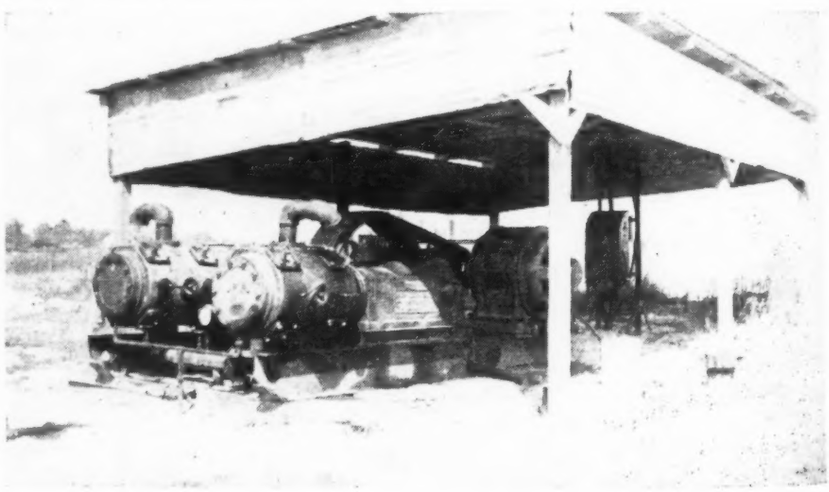


Fig. 4. A 100-hp. motor operating an air compressor in the Schuler field

In Northern Illinois

Purchased Electric Power is conveniently available for every purpose in the following counties:

STEPHENSON
BOONE
OGLE
DeKALB
WHITESIDE
LEE
MERCER
And Adjoining Counties

For Further Information Address

Illinois Northern Utilities Company

General Offices . . . Dixon, Illinois

BENJAMIN
TRADE MARK

LIGHTING EQUIPMENT

for Refineries, Pipe Line Stations, Oil and Gas Wells, etc.

Cat. No. 7513

Listed by Underwriters' Laboratories for Class I, Group D Hazardous Locations.

Write for special Data Sheets. Address Benjamin Electric Mfg. Co., Des Plaines, Ill.

Cat. No. 7520

Benjamin Lighting Equipment is Distributed Exclusively Through Electrical Wholesalers

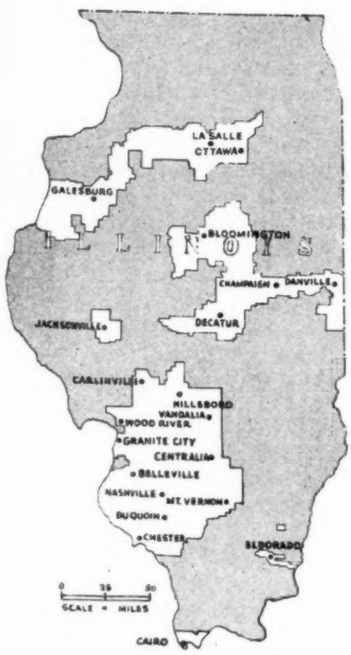
The Petroleum Engineer's "COMPOSITE MAP"

(34 x 44 inches)

SHOWING—
Electric Transmission Lines Serving the Oil Industry.
Location of Oil and Gas Fields.
Oil, Gas and Gasoline Pipe Lines.
Refineries.
In the Mid-Continent, Gulf Coast and Illinois Fields

PRICES
Regular paper stock $1.00
Mounted on linen 2.00
Mounted on linen with roller poles . 2.50

THE PETROLEUM ENGINEER
P. O. Box 1589 Dallas, Texas



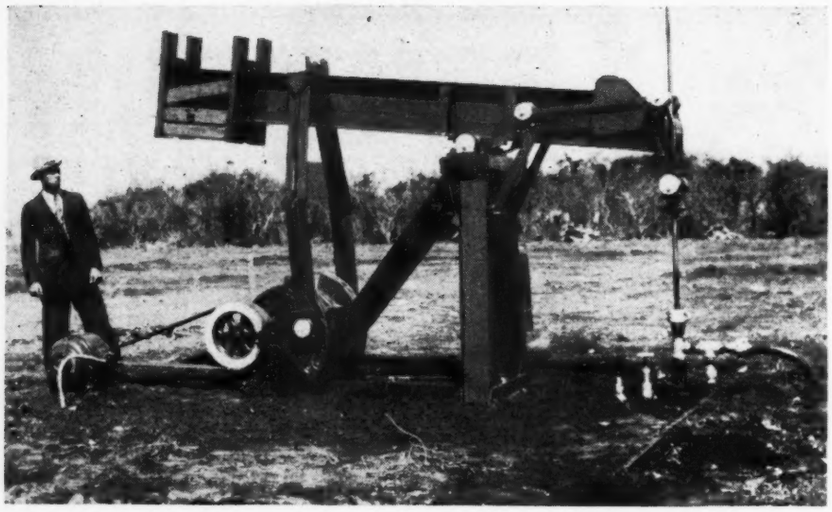
SAVE LARGE INITIAL INVESTMENT

and

Avoid Power Production Troubles . .

- You can accomplish these desirable results by using our electric service.
- The unshaded portions of the map represent the territories served by us.
- Get quick attention for your power problems by writing or 'phoning us or by visiting any of our offices in the cities shown on the map.

• ILLINOIS IOWA POWER COMPANY •



Typical 5-hp. motor on individual well; another well will be pulled by rod-line from this unit

PETROLEUM ENGINEER FEATURE

By NED W. BEAUDREAU

Central Power and Light Co., Corpus Christi, Texas

Southwest Texas Operators Recognize Value of Electric Power For Oil-Well Pumping

Electric power proves worth in pumping wells situated in remote territory—minimum attention permits pumpers to cover wide area

ONE of the most unusual and efficient pumping methods thus far developed is to be found in the Government Wells, Killam, and Oilton fields, in Duvall and Webb counties in Southwest Texas. These are shallow fields. The problem is that of producing wells in an isolated territory having limited allowable, and providing installations that will operate for many years without replacement.

In the Freer area of Government Wells no power lines were available at the outset. Some of the producers recognized the advantages of using electric power for the condition existing, and an interesting experiment of individual power plants operated by producers is underway. Enough experience has not been had to report on the economies of this method, but the four-, three-, and two-well hookups from each motor are apparently successful. Individual units are popular, and numerous geared powers are also being used. Because of the care exercised in proper counterbalancing of wells, most of the equipment, regardless of the number of wells pumped by each motor, operates efficiently with respect to power consumption. There is some question regarding the advisability of using rod lines and pump jacks, when small individual units and motors on each well entail little extra first cost, and permit simplified individual well-pumping operations and staggering of load.

NED W. BEAUDREAU

has been an industrial engineer with the Central Power and Light Company, Corpus Christi, Texas, for the last five years, working principally on electrification and power applications in the petroleum industry—Previously had been variously employed by the Shell Petroleum Corporation, the Texas Electric Service Company, and the California Company—He recently received an Edison Institute award for a paper on "The Benefits Derived From Uses of Electric Power."

In the Oilton and Killam fields of Webb County, producers are purchasing their power from a utility company. These wells are only 2000 ft. deep, and the reduction units used are inexpensive. Motors of 3 hp. are used on individual wells, 5-hp. motors on two-well hookups, and 7½- or 10-hp. motors on three-well and four-well hookups. Although there is little gas to assist in lifting the oil, there is also little salt water, and using a pumping speed of 12 to 16 s.p.m., the pumping motion is unusually smooth, and the load is 2 hp. per well or less.

It is interesting to note the cost of pumping these wells. The electric power cost average is about 1.5 cents per bbl. of oil produced, or less, and includes lease lighting, floodlighting of tank batteries for safety at night, and water-well pumping. The rates charged by the power company are designed on a sliding scale basis, so that as more wells are added the cost per well is less. Just as in any other business, it is explained that "mass production" of electric power enables lower cost; hence, this economy is passed on to producers in proportion to the volume of energy consumed.

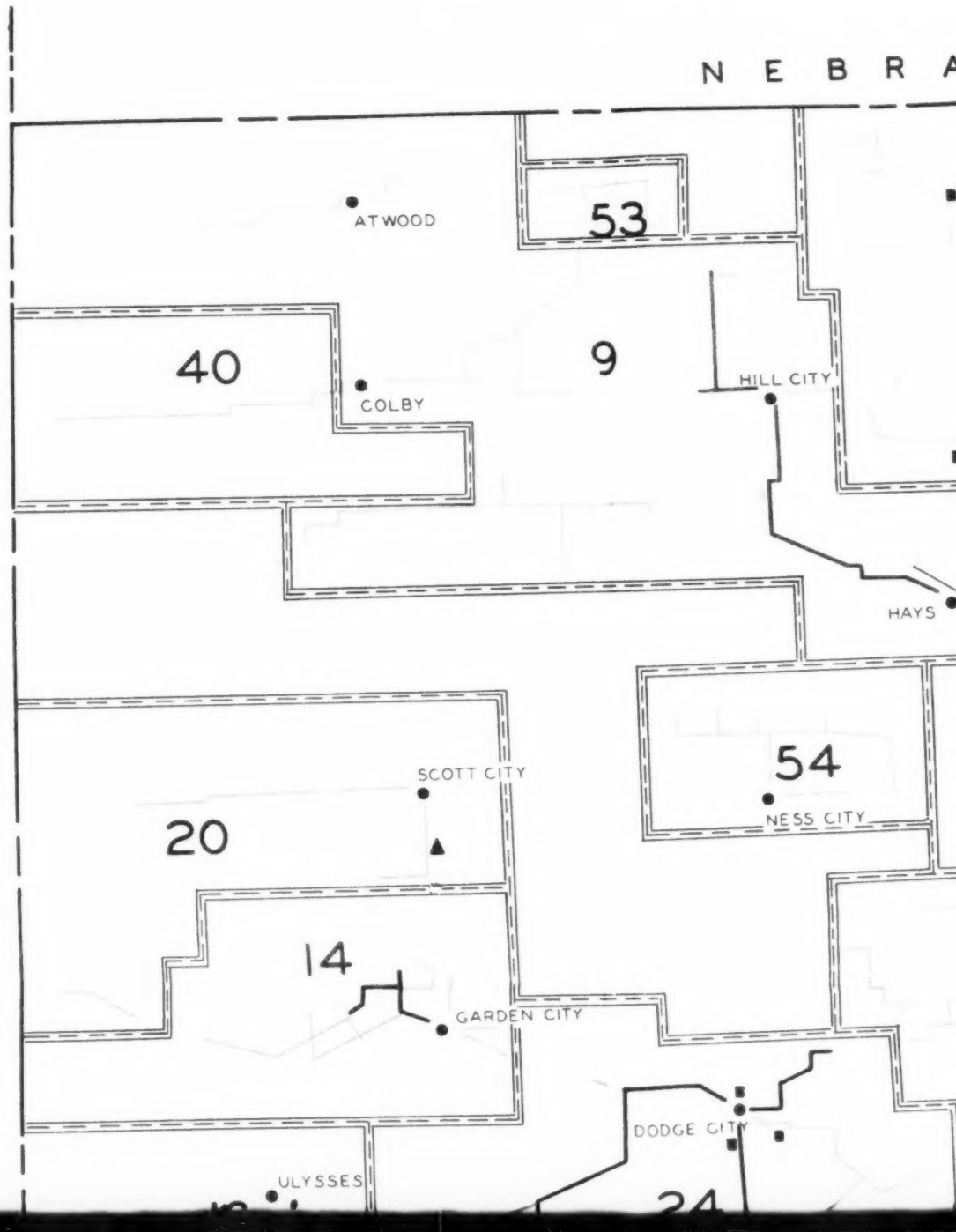
Many oil producers, having the facts and figures on the total production costs per bbl. of oil, especially for pur-

SUPPLEMENT to the June, 1939 ISSUE of THE

Single Copies of this Map ... Price $1.00 Each ... May

THE PETROLEUM ENG

700 ALLEN BUILDING

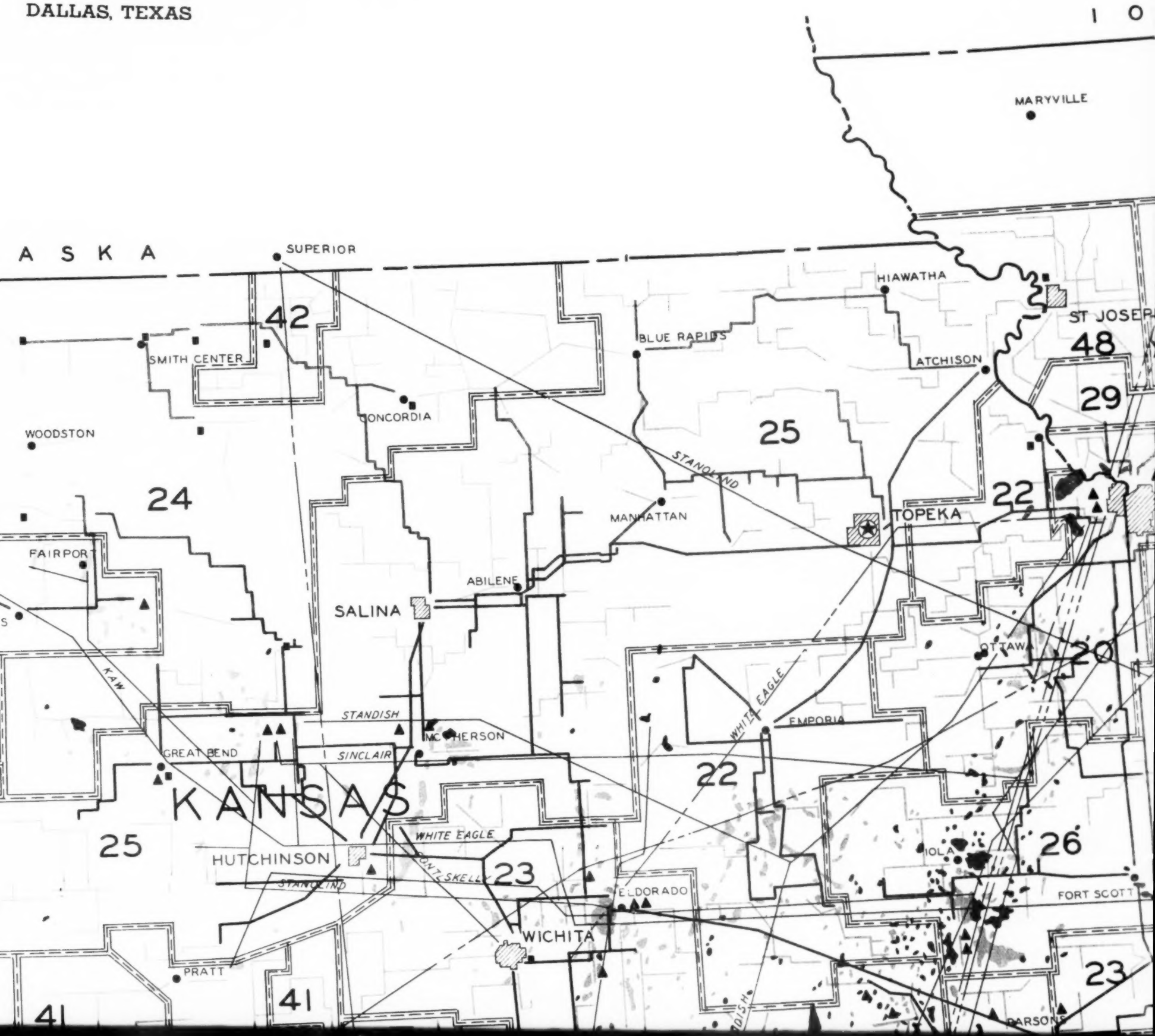


HE PETROLEUM ENGINEER

May be Obtained from

NGINEER

DALLAS, TEXAS



EER

IOWA

MARYVILLE

31

12

TRENTON

GREAT LAKES

HIAWATHA

CHILLICOTHE

30

ST JOSEPH

48

BLUE RAPIDS

ATCHISON

29

EXCELSIOR SPRS.

SINCLAIR

25

ORDIA

25

SINCLAIR-PRAIRIE

LEXINGTON

MARSH

STANOLIND

MANHATTAN

TOPEKA

22

KANSAS CITY

ABILENE

WARRENSBURG

OTTAWA

20

STANOLIND

32

CLINTON

WHITE EAGLE

EMPORIA

MC PHERSON

MISSOU

22

WHITE EAGLE

IOLA

26

NEVADA

HUMANSVILLE

23

ELDORADO

FORT SCOTT

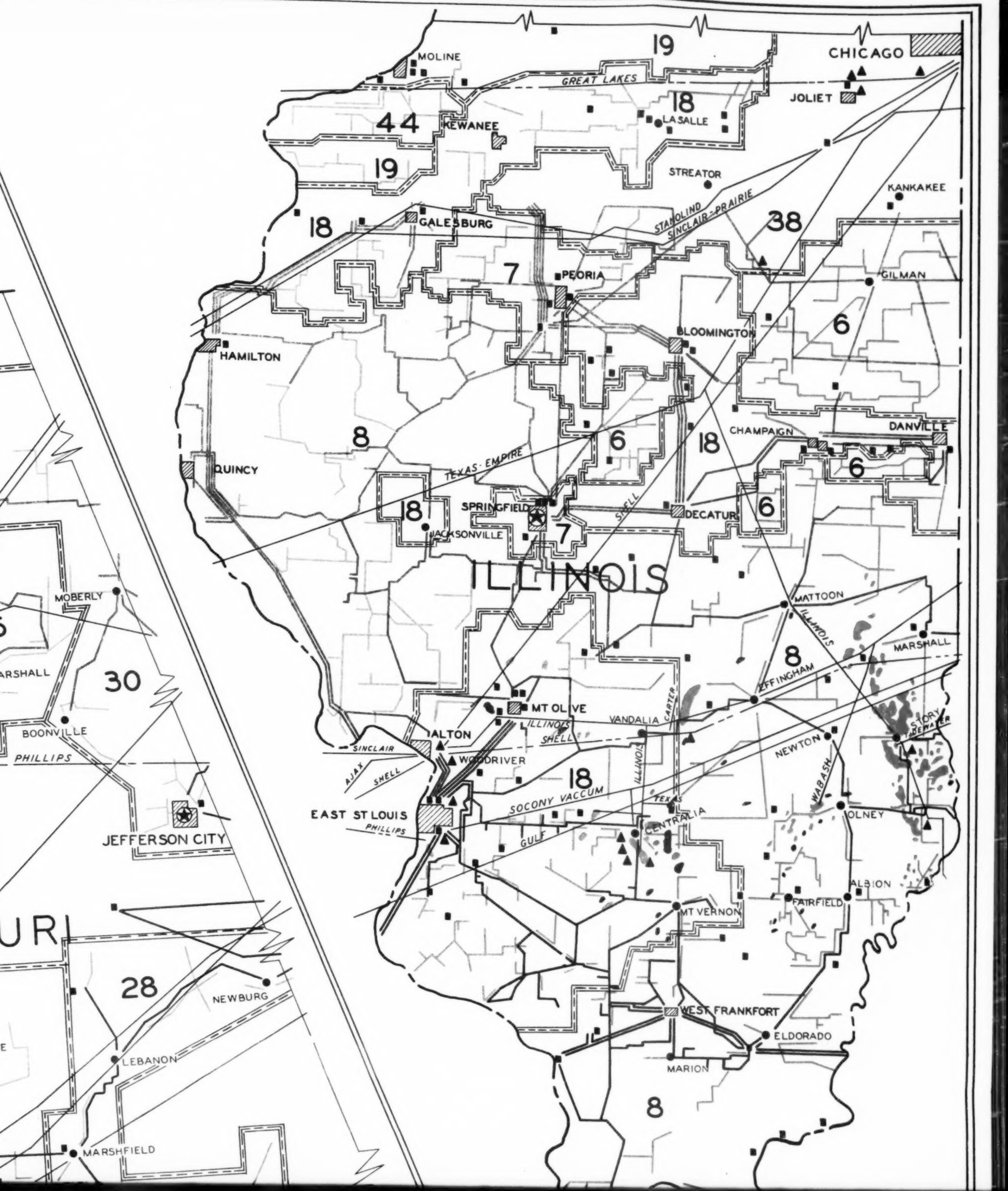
WICHITA

TEXAS-EMPIRE

23

13

PARSONS


MOLINE
GREAT LAKES
CHICAGO
JOLIET
LA SALLE
KEWANEE
STREATOR
KANKAKEE
GALESBURG
STANOLIND
SINCLAIR-PRAIRIE
PEORIA
GILMAN
BLOOMINGTON
HAMILTON
CHAMPAIGN
DANVILLE
QUINCY
TEXAS-EMPIRE
SPRINGFIELD
SHELL
DECATUR
JACKSONVILLE
ILLINOIS
MATTOON
MARSHALL
MOBERLY
EFFINGHAM
MT OLIVE
VANDALIA
CARTER
ILLINOIS
SHELL
ALTON
SINCLAIR
WOODRIVER
AJAX
SHELL
NEWTON
WABASH
SOCONY VACCUM
TEXAS
EAST ST LOUIS
CENTRALIA
OLNEY
PHILLIPS
GULF
ALBION
FAIRFIELD
MT VERNON
BOONVILLE
PHILLIPS
JEFFERSON CITY
WEST FRANKFORT
ELDORADO
MARION
NEWBURG
LEBANON
MARSHFIELD
19
18
44
19
18
7
38
6
8
6
18
6
18
7
8
30
18
28
8

14

GARDEN CITY

DODGE CITY

16

ULYSSES

24

HUGOTON

COLORADO

LIBERAL

KEYS

BOISE CITY

37

BEAVER

PHILLIPS

DALHART

37

STANDISH

ORGER

47

AMARILLO

SHAMROCK

ELK CIT

SINCLAIR

CLOVIS

CHILDRESS

TEX

PLAINVIEW

51

CROWELL

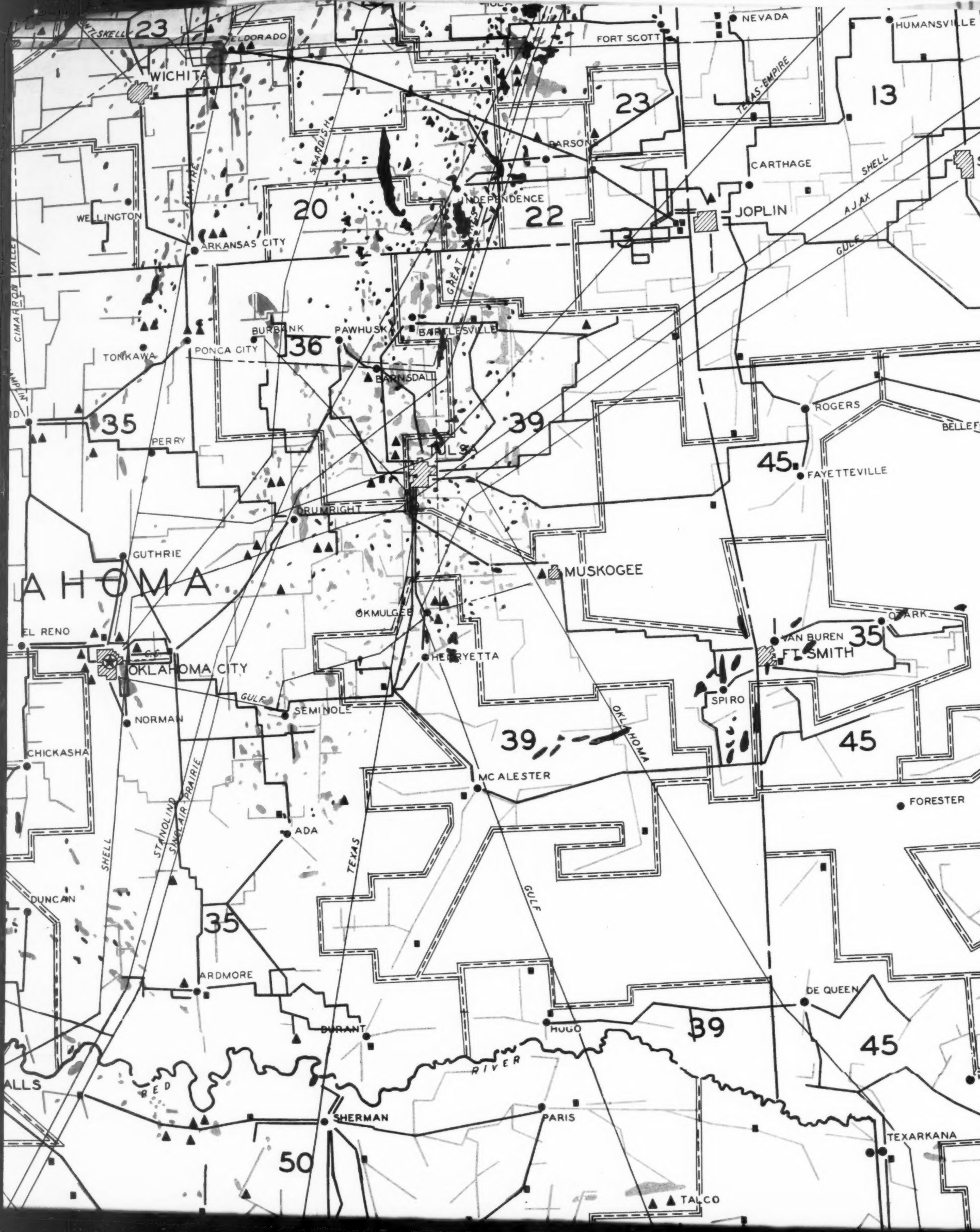
52

MAGNOLIA

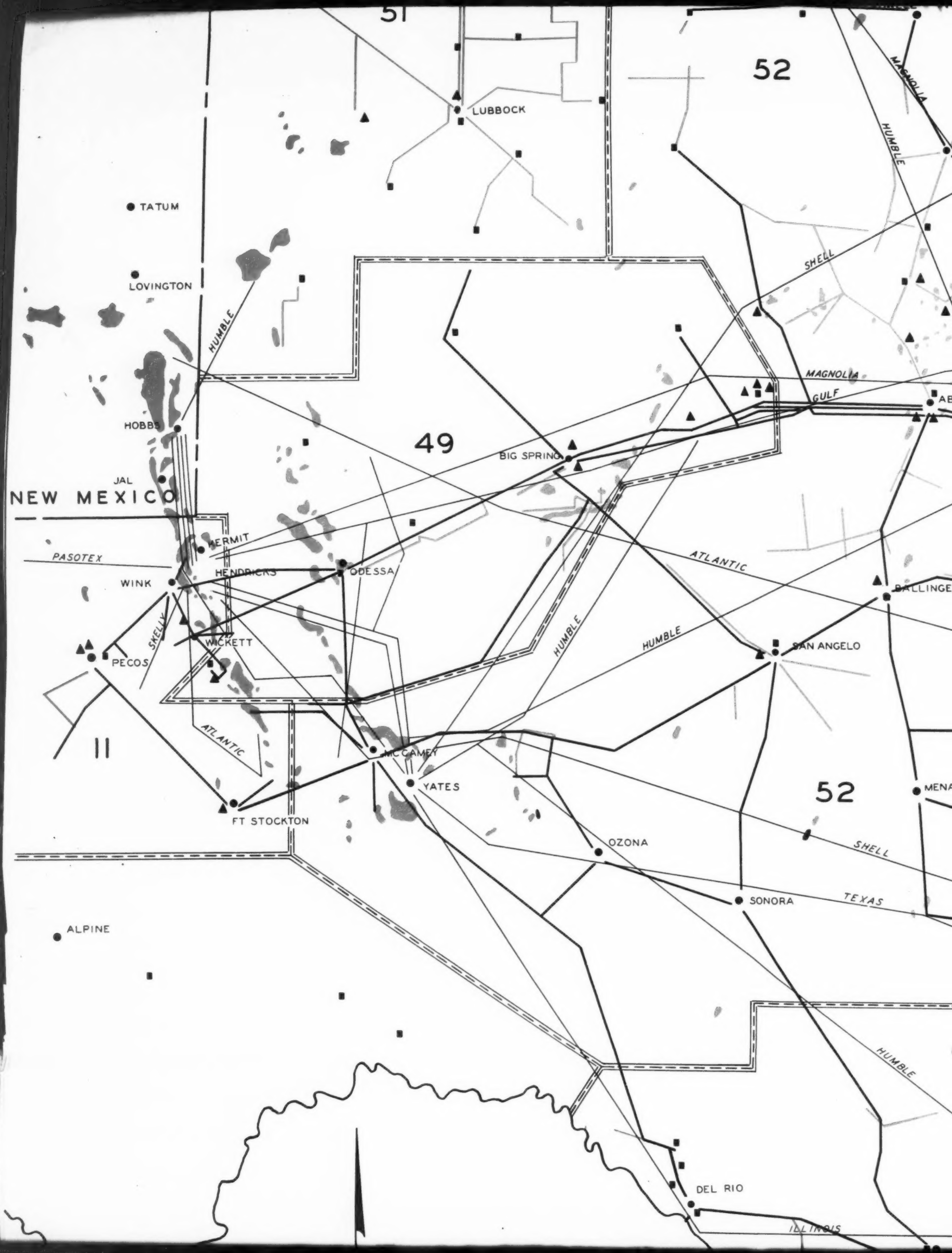
LUBBOCK

HUM

HUTCHINSON
STANOLIND
CONTSKELL
23
ELDORADO
FORT SCOTT
WICHITA
PRATT
41
41
23
PARSONS
MEDICINE LODGE
53
WELLINGTON
SEARSH
EMPIRE
20
INDEPENDENCE
22
ARKANSAS CITY
GREAT
ALVA
CIMARRON VALLEY
BURBANK
PAWHUSKA
BARTLESVILLE
TONKAWA
PONCA CITY
36
BARNSDALL
WOODWARD
CHAMPLIN
ENID
35
PERRY
39
TULSA
DRUMRIGHT
GUTHRIE
OKLAHOMA
MUSKOGEE
OKMULGEE
CLINTON
EL RENO
OKLAHOMA CITY
HENRYETTA
GULF
SEMINOLE
46
NORMAN
CHICKASHA
OKLAHOMA
39
HOBART
MC ALESTER
ADA
SHELL
STANOLIND
SINCLAIR-PRAIRIE
TEXAS
GULF
LAWTON
DUNCAN
35
ARDMORE
BURANT
HUGO
RIVER
RED
WICHITA FALLS
49
SHERMAN
PARIS
50


23
SKELLY
ELDORADO
WICHITA
FORT SCOTT
NEVADA
HUMANSVILLE
TEXAS-EMPIRE
13
23
PARSONS
SEARS-H
CARTHAGE
SHELL
AJAX
GULF
JOPLIN
WELLINGTON
20
22
INDEPENDENCE
ARKANSAS CITY
CIMARRON VALLE
GREAT
BURBANK
PAWHUSKA
BARTLESVILLE
TONKAWA
PONCA CITY
36
BARNSDALL
35
39
ROGERS
PERRY
TULSA
45
FAYETTEVILLE
DRUMRIGHT
GUTHRIE
MUSKOGEE
OKMULGEE
EL RENO
OKLAHOMA CITY
HENRYETTA
VAN BUREN
FT SMITH
35
SPIRO
GULF
SEMINOLE
NORMAN
OKLAHOMA
39
45
CHICKASHA
MC ALESTER
FORESTER
STANOLIND
SINCLAIR PRAIRIE
SHELL
ADA
TEXAS
GULF
DUNCAN
35
ARDMORE
DE QUEEN
DURANT
HUGO
39
45
RED
RIVER
SHERMAN
PARIS
TEXARKANA
50
TALCO

LEBANON
MARSHFIELD
SPRINGFIELD
28
WILLOW SPRINGS
MARION
8
CAIRO
1
FORSYTH
2
3
WALNUT RIDGE
PARAGOULD
BLYTHEVILLE
1
NEWPORT
MEMPHIS
TENNESSEE
RUSSELLVILLE
JUDSONIA
2
ARKANSAS
LITTLE ROCK
CLARENDON
3
RIVER
MISSISSIPPI
HOT SPRINGS
PINE BLUFF
GURDON
2
MC GEHEE
MONTICELLO
HOPE
CAMDEN
SMACKOVER
EL DORADO
STANDARD LA.


51
52
LUBBOCK
MAGNOLIA
HUMBLE
TATUM
LOVINGTON
HUMBLE
SHELL
MAGNOLIA
GULF
HOBBS
49
BIG SPRING
JAL
NEW MEXICO
HERMIT
PASOTEX
ATLANTIC
WINK
HENDRICKS
ODESSA
SKELLY
WICKETT
PECOS
HUMBLE
HUMBLE
SAN ANGELO
ATLANTIC
11
MCCAMEY
YATES
52
FT STOCKTON
OZONA
SHELL
SONORA
TEXAS
ALPINE
HUMBLE
DEL RIO
ILLINOIS

WICHITA FALLS
RED
SHERMAN
PARIS
49
50
MUNDAY
DENTON
GREENVILLE
GULF
MINERAL WELLS
TERRELL
MINEOLA
BRECKENRIDGE
FT. WORTH
DALLAS
RANGER
TYLER
ABILENE
CISCO
TRINIDAD
CORSICANA
HILLSBORO
GULF
JAC
HICO
PALESTINE
BROWNWOOD
HAMILTON
MEXIA
SINCLAIR-PRAIRIE
TEXAS
MAGNOLIA
WACO
TEXAS
LAMPASAS
TEMPLE
50
MENARD
PEARNE
CAROLINA
TAYLOR
ATLANTIC
HUMBLE
AUSTIN
BRENHAM
BASTROP
TEXAS
GULF
MAGNOLIA
KERRVILLE
SAN MARCOS
LOCKHART
SHELL
LULING
NEW BRAUNFELS
43
17
GRAYBURG
HUMBLE
SAN ANTONIO
WHARTON
QUERO

ALLS
RED
SHERMAN
PARIS
TEXARKANA
50
TALCO
DENTON
GREENVILLE
RODESSA
45
GULF
MINERAL WELLS
TERRELL
MINEOLA
MARSHALL
DALLAS
FT. WORTH
LONGVIEW
TYLER
HENDERSON
TRINIDAD
CORSICANA
CITIES SERVICE
HILLSBORO
GULF
JACKSONVILLE
MAGNOLIA
HICO
PALESTINE
50
HAMILTON
MEXIA
SINCLAIR-PRAIRIE
TEXAS
MAGNOLIA
NACOGDOCHES
WACO
LUFKIN
GULF
TEXAS
X/A S
TEMPLE
LAMPASAS
50
TEARNE
SAN JACINTO
15
HUMBLE
TAYLOR
ATLANTIC
CONROE
AUSTIN
HUMBLE
BEAUMONT
BRENHAM
BASTROP
TEXAS
GULF
MAGNOLIA
HOUSTON
PORT ARTHUR
N MARCOS
LOCKHART
SHELL
BAYTOWN
LULING
17
TEXAS CITY
GRAYBURG
HUMBLE
GALVESTON
ANTONIO
WHARTON
QUERO
F

CAMDEN

SMACKOVER

EL DORADO

STANDARD LA.

BASTROP

HOMER

SHREVEPORT

MONROE

27

4

STANDARD LA.

LOUISIANA

MISSISSIPPI

4

4

CONTINENTAL

5

27

BATON ROUGE

TEXAS

REPUBLIC

LAFAYETTE

LAKE CHARLES

SHELL

NEW IBERIA

27

NEW ORLEANS

ORANGE

15

M E X I C O

QUERO

ALPINE

SONORA

TEXAS

HUMBLE

DEL RIO

ILLINOIS

EAGLE PASS

RIO GRANDE

RIVER

N

-LEGEND-

ELECTRIC TRANSMISSION LINE 33 KV.-OVER

ELECTRIC TRANSMISSION LINE 22 KV.-UNDER

ELECTRIC SUB STATION

50 — DENOTES AREA SERVED BY ELECTRIC UTILITY COMPANY
SEE KEY LIST OF NUMBERS FOR UTILITY COMPANY SERVING AREA.

OIL FIELD

GAS FIELD

TEXAS — OIL TRUNK PIPE LINE

PHILLIPS — GASOLINE TRUNK PIPE LINE

REFINERY

SCALE

0 20 40 60 80 MILES

DRAWN BY
W. VAN TUYL CO. DALLAS, TEXAS.

AUSTIN
BASTROP
BRENHAM
KERRVILLE
SAN MARCOS
LOCKHART
LULING
NEW BRAUNFELS
SAN ANTONIO
GRAYBURG
HUMBLE
TEXAS
GULF
MAGNOLIA
SHELL
ATLANTIC
WHARTON
BAY CITY
QUERO
VICTORIA
UVALDE
THREE RIVERS
BEEVILLE
ENCINAL
INGLESIDE
ALICE
CORPUS CHRISTI
CORPUS CHRISTI
LAREDO
MIRANDO CITY
CRUDE OIL
FALFURRIAS
MC ALLEN
HARLINGEN
VALLEY
BROWNSVILLE
43
17
10

MAP SHOW

ELECTRIC POWER TRAN

OIL and GAS

REFINERI

and

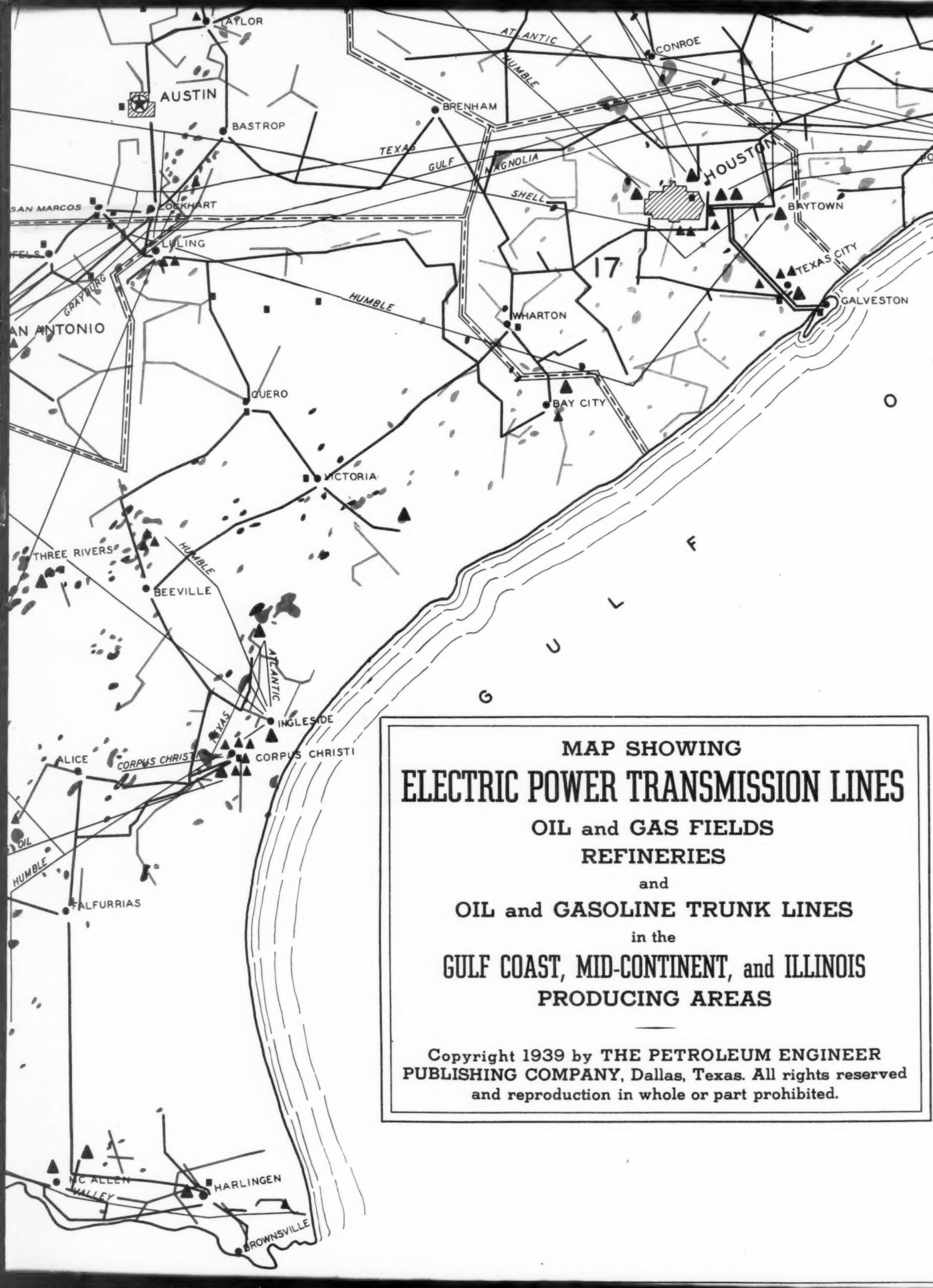
OIL and GASOLINE

in the

GULF COAST, MID-CONTIN

PRODUCING

Copyright 1939 by THE PETR
PUBLISHING COMPANY, Dallas,
and reproduction in whole



MAP SHOWING

ELECTRIC POWER TRANSMISSION LINES

OIL and GAS FIELDS

REFINERIES

and

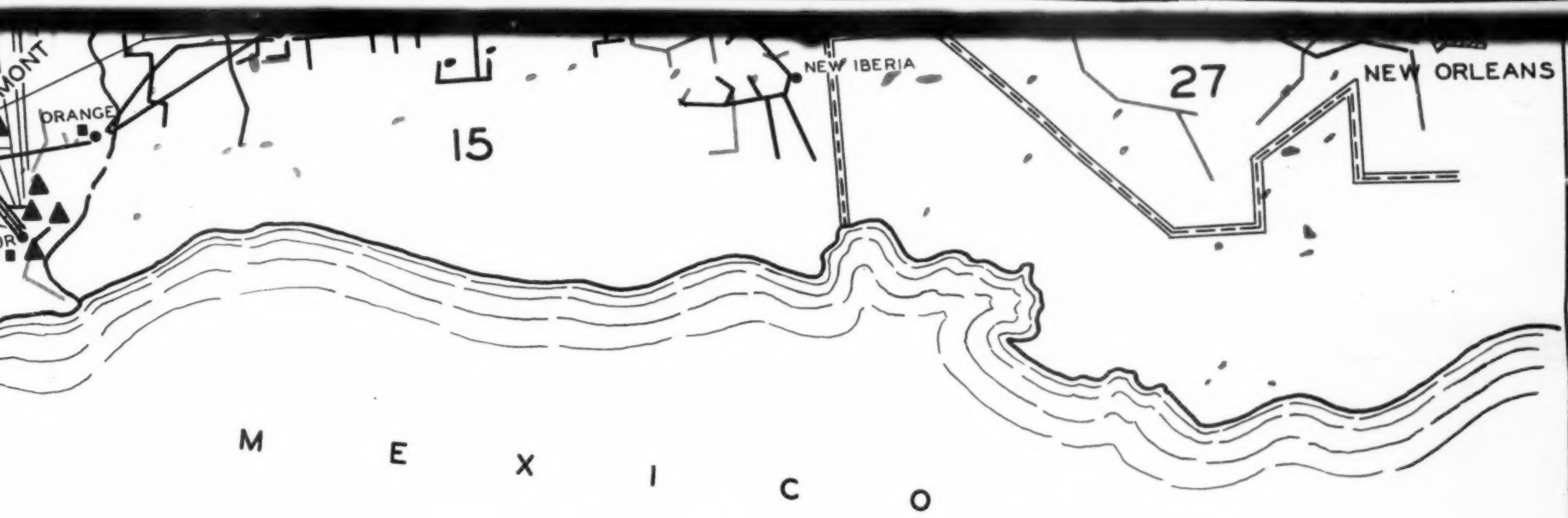
OIL and GASOLINE TRUNK LINES

in the

GULF COAST, MID-CONTINENT, and ILLINOIS PRODUCING AREAS

Copyright 1939 by THE PETROLEUM ENGINEER PUBLISHING COMPANY, Dallas, Texas. All rights reserved and reproduction in whole or part prohibited.

1. Ark
2. Ark
3. Ark
4. Ass
5. Bat
6. Cer
7. Cer
8. Cer
9. Cer
10. Cer
11. Cor
12. Cor
13. Em
14. Gar
15. Gul
16. Hig
17. Hou
18. Illi
19. Illi
20. Inl
21. Kar
22. Kar
23. Kar
24. Kar
25. Kar
26. Kar
27. Lou



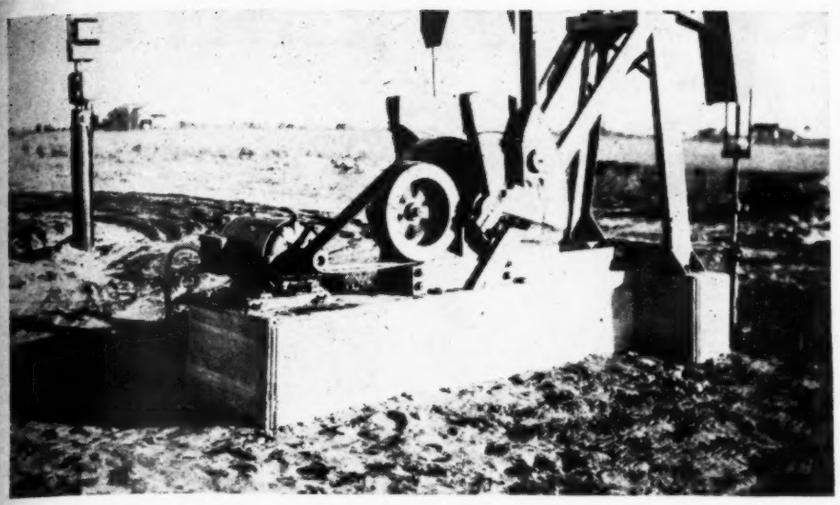
KEY LIST OF ELECTRIC UTILITY COMPANIES

(Area served by each utility company is designated on the map by a number that corresponds with number on key list.)

Arkansas-Missouri Power Corporation . . . . Blytheville, Ark.
Arkansas Power and Light Company . . . . Pine Bluff, Ark.
Arkansas Utilities Company . . . . . Helena, Ark.
Associated Gas and Electric System . . . . . Ithaca, N. Y.
Baton Rouge Electric Company . . . . . Baton Rouge, La.
Central Illinois Electric and Gas Company . . . Rockford, Ill.
Central Illinois Light Company . . . . . Peoria, Ill.
Central Illinois Public Service Company . . . Springfield, Ill.
Central Kansas Power Company . . . . . Abilene, Kan.
Central Power and Light Company . . . Corpus Christi, Texas
Community Public Service Company . . . . Fort Worth, Texas
Consumers Public Service Company . . . . . Brookfield, Mo.
Empire District Electric Company . . . . . Joplin, Mo.
Garden City Company . . . . . Garden City, Kan.
Gulf States Utilities Company . . . . . Beaumont, Texas
Highland Utilities Company . . . . . Springfield, Colo.
Houston Lighting and Power Company . . . . Houston, Texas
Illinois-Iowa Power Company . . . . . Monticello, Ill.
Illinois Northern Utilities Company . . . . . Dixon, Ill.
Inland Utilities Company . . . . . Chicago, Ill.
Kansas City Power and Light Company . . . Kansas City, Mo.
Kansas Electric Power Company . . . . . Lawrence, Kan.
Kansas Gas and Electric Company . . . . . Wichita, Kan.
Kansas Power Company . . . . . Great Bend, Kan.
Kansas Power and Light Company . . . . Hutchinson, Kan.
Kansas Utilities Company . . . . . Fort Scott, Kan.
Louisiana Power and Light Company . . . . . Algiers, La.

28. Missouri Electric Power Company . . . . . Tulsa, Okla.
29. Missouri Gas and Electric Service Company . . Lexington, Mo.
30. Missouri Power and Light Company . . . . Jefferson City, Mo.
31. Missouri Public Service Company . . . . . Warrensburg, Mo.
32. Missouri Public Service Corporation . . . . Warrensburg, Mo.
33. Mount Carmel Public Utility and Service Co. . Mount Carmel, Ill.
34. Northern Power and Light Company . . . . . Huron, S. D.
35. Oklahoma Gas and Electric Company . . Oklahoma City, Okla.
36. Oklahoma Power and Water Company . . Sand Springs, Okla.
37. Panhandle Power and Light Company . . . . . Borger, Texas
38. Public Service Company of Northern Illinois . . . Chicago, Ill.
39. Public Service Company of Oklahoma . . . . . Tulsa, Okla.
40. Public Utilities Company . Thomas and Sherman Counties, Kan.
41. Rezeau Brothers Company . Pratt and Kingman Counties, Kan.
42. State Rural Electrification Authority . . . Jewell County, Kan.
43. San Antonio Public Service Company . . San Antonio, Texas
44. Sherrard Power Co. . Rock Island, Mercer, and Henry Counties, Ill.
45. Southwestern Gas and Electric Company . . Shreveport, La.
46. Southwestern Light and Power Company . . Chickasha, Okla.
47. Southwestern Public Service Company . . . . Amarillo, Texas
48. St. Joseph Ry., Lt., Ht. & Power Company . . . St. Joseph, Mo.
49. Texas Electric Service Company . . . . . Fort Worth, Texas
50. Texas Power and Light Company . . . . . Dallas, Texas
51. Texas Utilities Company . . . . . Plainview, Texas
52. West Texas Utilities Company . . . . . Abilene, Texas
53. Western Light and Telephone Company . . Kansas City, Kan.

PRINTED IN U. S. A.



A 2000-ft. well being pumped by a 3-hp. splashproof motor

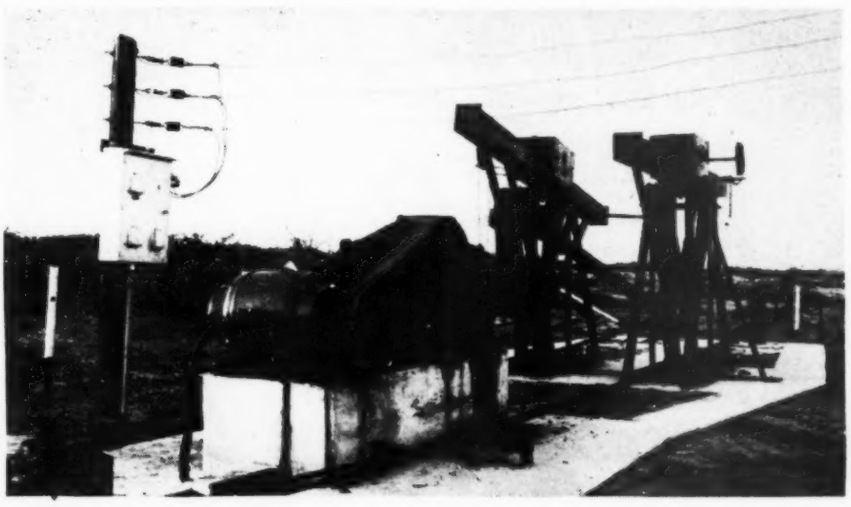
chased power, are interested in the outcome of these electric power pumping operations. Such costs are difficult to obtain, principally because well-servicing costs are not consistent and do not represent average conditions; also, because the costs of the original leases and of drilling the wells are not definitely known. Production costs, including labor, miscellaneous repairs, power cost, interest on investment, depreciation on pumping investment, pumpers' residence, lease lighting, water-well, and gathering costs, however, are averaging between 4 and 5 cents per bbl. on small leases, and less on larger leases. This is less than five percent of the market price of the oil.

The item of labor cost is not definitely established because the number of wells each pumper can properly operate using electric power is not known. Owing to the simplicity in starting and the minimum attention required in operating, wells can be pumped automatically, the well motor being started and stopped at any predetermined time. As many as 40 or 50 wells using individual units can be pumped by one workman. The opportunity for economy in production cost is obvious, as one man must be used whether he pumps four wells or forty. Virtually no repair or maintenance work is necessary on the power end of these installations, because an electric motor of the squirrel-cage induction type has only one moving part, the rotor, which has two bearings; these require lubrication only a few times per year. The most satisfactory performance seems to be obtained using motors designed for higher starting torque than the general-purpose motor. These motors have higher slip and withstand the fluctuating load that is characteristic of oil-well pumping, even at slower speeds. Another feature of these motors that results in economy is the weatherproof design. The weatherproof motor is called splashproof and will operate in the open without housing.

Many operators purchase any kind of switch for starting and stopping the motor. This it not good practice. It is economy in the long run to purchase waterproof fused entrance switches and starters. Most of the smaller sizes of motors require only cross-the-line starters, in which case preference should be given to magnetic starting switches having push-button control. This simplifies remote control, and if automatic starting and stopping is desired on the wells at a later date the time-switch can easily be inserted in the start-stop control circuit. Regardless of the type of switch purchased, it is important to have the proper protective devices, which will positively eliminate danger of trouble caused by overloading the motor. Push-button controls for starting and stopping the motor manually are most convenient when placed near the brake lever of the pumping unit, so that one workman can operate and stop the unit at the desired polished-rod position when setting clamp, hooking-off, etc.

In the Oilton and Killam fields, the power company builds 11,000-volt primary lines into the fields to a convenient location on the lease to be served, and supplies the necessary transformers to deliver the power at 440 volts. The customer builds his own 440-volt distribution system from that point to the motors on wells to be pumped, and installs a 440-volt to 110-volt or 220-volt transformer for lighting and small single-phase power. Poles, 30 ft. in height, ordinarily are used and insulated wire, although some producers are using 35-ft. poles and bare copper wire. The cost for either is about the same.

Much consideration is given by those unfamiliar with electric power operation to the dangers involved. In the writer's 12 years' experience in the fields, not one serious injury has been observed on the type of service just described (440-volt, three-phase, secondary service) because the power company owns, installs, and maintains the high-voltage equipment, and the customer has to use only the low-voltage equipment. Some major companies who have in their employ competent electrical men, of course, find it economical to build their own lines and maintain their own high-voltage transformers, because power companies offer lower "primary" rates for this class of service. This is due to the investment required for primary transformer installations, and the hazards of loss by lightning and other causes, and dangers to men working on high-voltage. The practice of using 440-volt systems for oilfield operations is recommended to producers.



One motor pumping four wells

THOUSANDS OF OPERATORS EVERYWHERE . . .

The fact that more and more operators are turning to Purchased Electric Power for use in production, pipeline, refining and many other purposes is evidence that it is getting the job done more efficiently for less money! Purchased Electric Power can get outstanding results for you, too. Just ask your nearest electric power company for facts concerning your power problems. A sincere and helpful counsel is offered without any obligation on your part.

POWER—WHEN YOU NEED IT—AT A COST WHICH ALLOWS LARGER PROFITS!

PETROLEUM ELECTRIC POWER ASSOCIATION

Box 1498, Oklahoma City, Oklahoma

P 362.5
P 409.1

Aerial view of Huntington Beach field, California

(Photo courtesy Fairchild Aerial Surveys, Inc.)

PETROLEUM ENGINEER EXCLUSIVE FEATURE

By
HERBERT
THAYER BRUCE

Recent Improvements in Technique of Aerial Photography

Part 2 (Concluded)

EQUIPPED with a solar navigator, a plane may start from any known control point such as an astronomical station and carry triangulation far into the interior of an unmapped country, taking a series of photographs at all points where triangulation flight lines intersect. In this way a triangulation net may be constructed by means of which accurate control for an aerial survey map may be established in inaccessible regions. The accuracy of the solar navigator eliminates the error of merely matching images of one picture with those of the next in order to assemble a mosaic. In the petroleum industry aerial maps have been used to good advantage in the last few years in geological exploration of presumed oil-bearing strata, fissures or large areas where oil seeps have been reported in regions inaccessible for large exploration parties or of which there are no maps available for explorative guidance. The complicated area at Kettleman Hills, California, is an example of the type of country where aerial mapping is invaluable.

Some of the details of the actual preparation of an aerial survey should be of interest to those who have never had occasion to study the subject. The scale of each survey is optional. The altitude at which the plane must fly is determined by the scale at which the area is to be mapped and the focal length of the lens to be used. Let us assume a scale of 3000 ft. to the inch is decided upon. For the 3000-ft. scale, using a lens of 6-in. focal length, the altitude must be 18,000 ft. above the terrain, not above sea level. The altitude is determined by multiplying the desired scale of the map by the focal length of the lens: 3000 × 6. This height will, in a single exposure, permit a photograph to be taken of a ground width of about 27,000 ft.; however, cross winds and air pockets will usually reduce the useful width of the photograph to approximately 18,000 ft. Before flight an outline of the area to be covered is drawn on maps (if available) and notations are made for flight guide-lines between landmarks on the terrain such as cliffs, peaks, or river junctions. The pilot flies along these flight guide-lines until the entire area has been completely covered by successive strips of overlapping exposure. Each exposure is made on a 9-in. by 9-in. film. The overlapping of exposures reduces the net effective area of each picture by about 64 percent. The photographer must time his exposures to overlap shingle-wise by about 60 percent and the pilot must plan the flight guide-lines so that the exposed strips of terrain overlap by about 40 percent. This overlap is necessary for the purpose of accurate mapping. Each photograph shows in addition to the objects directly beneath the camera the objects that were directly beneath the camera during the next previous and next following exposures. This overlapping corrects the distortion caused by the increasing distance at the edges of a single picture resulting from the effect of the earth's curvature.

In assembling the mosaic map there are five major steps. (1) Scale ratio is carefully determined on a set of contact prints by checking distances between known points on the actual terrain with the same distances as shown on the photographs. This check determines the inaccuracies caused by the side slip or rise and fall of the plane. (2) The next step is the projection of the negatives to produce ratio prints

A biographical sketch and photograph of the author can be found on page 31 of the May issue of *The Petroleum Engineer*, in connection with Part 1 of this article.

having a common scale. (3) On a composite board the center point of each ratio print and control lines are indicated in pencil to the desired scale of the map, the control lines being determined by triangulation points on the terrain taken from field maps, road maps, or other accurate sources. (4) The common-scale prints are then cut on these lines that preferably are determined by physical features of the terrain, forest boundaries, for instance. The portions of print are then cemented to the control board in accordance with the penciled control lines. (5) This makes a master mosaic that is then rephotographed. Photographs of sections of the master mosaic may be made, each about 20 in. by 24 in. for convenient handling. They may be enlarged to produce greater detail, used individually without enlargement, or put together to make one continuous map.

When completed they are delivered to the geologist or engineer. Overlapping prints from the original negative may be viewed stereoscopically. The stereoscope used for this purpose is a two-mirror device that blends into one image two pictures of an assembled mosaic from slightly different points of view so as to produce upon the eye the impression of relief. Stereoscopic study is amazing to those not conversant with its use. When using the stereoscope to view the aerial map one sees the terrain as would a giant towering three or four miles in height with eyes a mile apart. Stereoscopic plotting machines such as the "stereoplanigraph" may be used to plot precise contour maps reproducing the exact elevation of each detail of the aerial photograph. Contour maps may be made by this device to any desired scale. Scales have varied from as large as 20 ft. per in. to as small as 2 mi. per in. Under most conditions contour maps may be made by this method more economically than by conventional ground surveys and to the same, or even to a greater degree of accuracy.

It is difficult to generalize concerning aerial mapping costs. There is no rule of thumb method of computation or of striking an average. Each aerial survey job is dependent upon the individual conditions. There is the consideration of the type of plane to be used. Probable weather conditions must be considered. The scale of map desired effects the cost. Cost of maps has ranged as high as $50,000. Some government survey maps have cost as low as $4.00 per square mile at a scale of 2 in. to the mile. Those concerned about cost are also concerned with results. When the desired result is obtained, cost is sometimes secondary. Aerial survey costs, generally speaking, have proved to be lower in many instances than ground survey costs.

It is nearly 20 years since the aerial photographic survey came into being. The pioneer aerial photographers of the World War who used "Sausage" balloons, Jennies, Breguits, and Nieuports for photographic reconnaissance would marvel at the supercharged, oxygen-equipped Fairchilds, Sikorskies, Boeings, and other planes used today for petroleum engineering surveys in the Dutch East Indies, Bolivia, New Guinea, Mexico, and in the United States. The changes that have taken place in equipment and operation during the last three and four years are in response to the demands of industrial customers for exceptional results. Those in the petroleum industry are among the most exacting because their needs are greatest. Industrial aviation and the scientific development of aerial photographic surveys is demonstrating an ability to meet these needs.

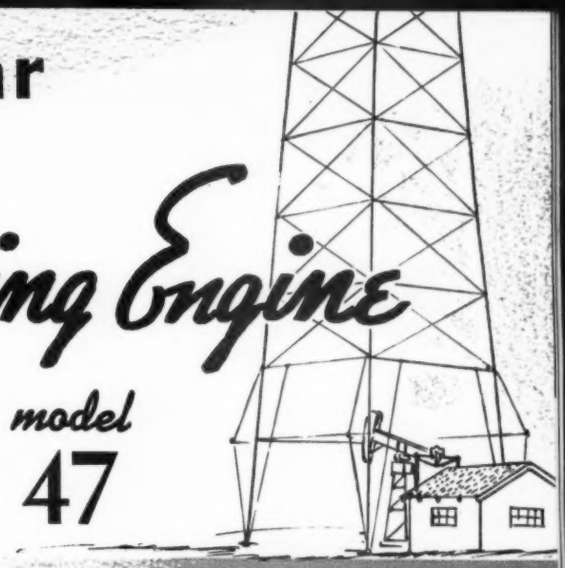
Aerial photographs such as this aided in the early studies of Kettleman Hills, California

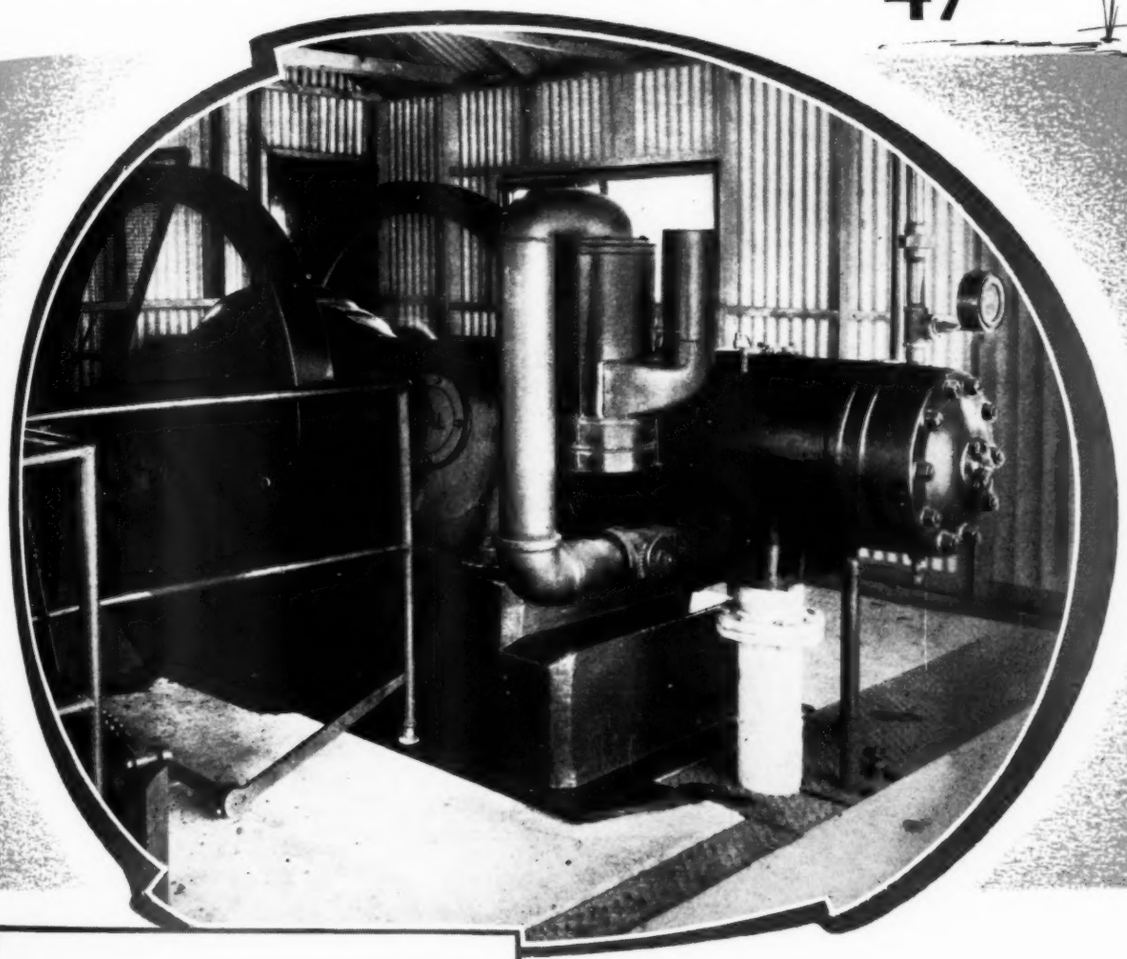
(Photo courtesy Fairchild Aerial Surveys, Inc.)

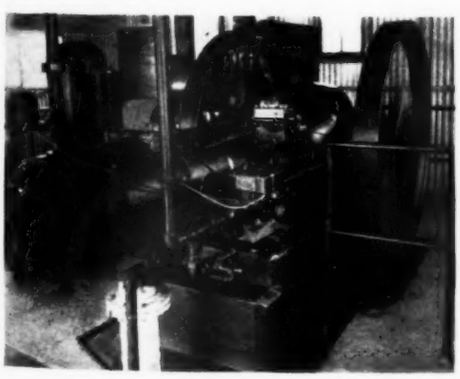
Year After Year

An Outstanding Pumping Engine

FAIRBANKS-MORSE *model* 47







● Positive, force-feed lubrication, combined with a splash system, affords ample lubrication throughout the entire speed range.

● Available for operation on either oil or gas, the Model 47 is quickly and easily convertible to either fuel with minimum expense.

WHETHER it's pulling rods or tubing . . . running a bailer . . . drilling deeper . . . or straight pumping—you can rely on the dependability of the Fairbanks-Morse Model 47 Pumping Engine. The simple, two-cycle, slow-speed design has long appealed to the practical man who appreciates fundamental simplicity with freedom from frequent repair bills.

With extra-heavy flywheels and an oil field type governor, the Model 47 engine affords an exceptionally smooth pumping cycle, regardless of well conditions. Its wide speed range and reserve power particularly suit it for heavy-duty well servicing operations. Your nearest Continental representative will gladly furnish you complete information.

THE CONTINENTAL SUPPLY COMPANY

Export Office: CONTINENTAL EMSCO CO., Inc.
30 Rockefeller Plaza New York City, N. Y.

Representatives:

LONDON TRINIDAD MARACAIBO
TAMPICO BUENOS AIRES

CONTINENTAL

"Serving the Oil and Gas Industries"

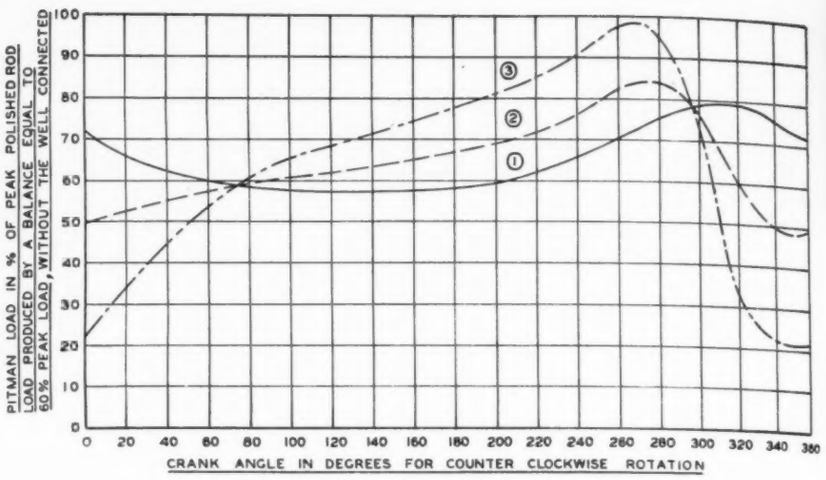


Fig. 13. Pitman load produced by counterweight with no well load. Legend: (1) very slow speed. (2) 20 s.p.m. (3) 30 s.p.m.

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

A Comparison of Rotary, Beam, and Pneumatic Counterbalances

Part 2 (Concluded)

By

KENNETH N. MILLS

Chief Engineer, American Manufacturing Company of Texas

When the rotary counterbalance is used, the undiminished well load is imposed on the pitman and its bearings, but when the pneumatic or beam type counterbalance is used, it tends to reduce the magnitude of the load imposed on the pitman and its bearings, as either type exerts a force that opposes the well load. The reduction in pitman load resulting from use of the beam balance depends upon the rate of acceleration at the weight, and hence upon the operating speed. The magnitude of the force imposed on the pitman by a beam weight whose counterbalance effect equals 60 percent of the peak well load is shown in Fig. 13. The force shown on this curve is opposed to the force created by the well load. This property of the beam balance cannot be utilized because it increases the range of the pitman load and places the pitman in compression during the downward portion of the pumping cycle. As it causes the pitman strain to change from compression to tension, it can cause difficulty with the bearings used on this member.

The chief disadvantage of the rotary counterbalance is that it imposes much greater loads on the crankshaft than does either the pneumatic or beam type counterbalance. The amount of this increase in crankshaft loading depends upon the pumping speed and the general design of the crank. The mathematical expressions for the bending moments imposed on the slow speed shaft by a rotary counterbalance are:

A biographical sketch and photograph of the author can be found on page 42 of the May issue of *The Petroleum Engineer*, in connection with Part 1 of this article.

Moments in horizontal plane (MH)

$$MH = CF \times C - PH \times D \quad (2)$$

Moments in vertical plane (MV)

$$MV = \frac{W \times B \times C}{A} + \left[\frac{PV - W\,(A + B)\,C}{A \times D}\right] D \quad (3)$$

Wherein

A, B, C, D = dimensions indicated in Fig. 14, in.

PH = Horizontal component of pitman pull, lb.

PV = Vertical component of pitman pull, lb.

W = Weight of crank, lb.

CF = Centrifugal force

$$= \frac{W \pi^2 N^2 r}{900\ g}$$

N = Speed of crank, r.p.m.

r = Radius to center of gravity of crank, ft.

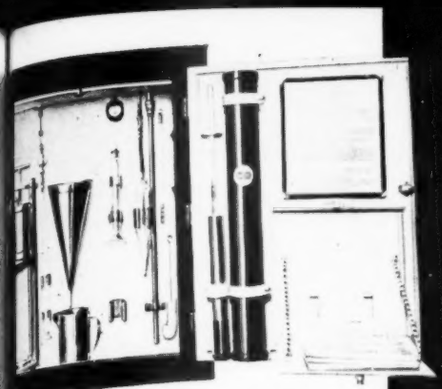
If the beam or pneumatic type of counterbalance is used, the equations for the crankshaft bending moment are:

$$MH = PH \times D \quad (4)$$

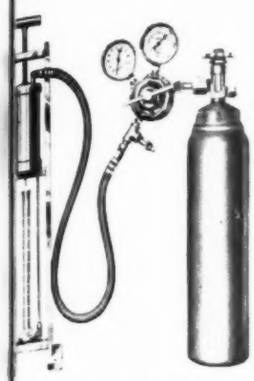
$$MV = PV \times D \quad (5)$$

Comparing equations 2 and 4, it is evident that the bending moment in the horizontal plane is much less if the beam counterbalance is used than it is if the rotary counterbalance is used, as centrifugal force does not affect the beam or pneumatic balance. On comparing the moment equations for the vertical plane, it is evident that the same condition exists, because in the case of the beam balance, the moment due to the reaction of the counterweight mass does not appear in equation 5. The magnitude of these forces is great in actual practice, and they are important considerations. For a given amount of counterbalance effect on a given crank, the centrifugal force is proportional to the square of the speed of the crank, and it reaches astounding proportions at great operating speed. Furthermore, the magnitude of the pitman pull is less if the beam or pneumatic counterbalance is used than it is if the rotating counter-

DRILLING MUD
TESTING EQUIPMENT
THE MEANS TO BETTER MUD CONTROL



Baroid Field Cabinet For Mud-Testing Equipment

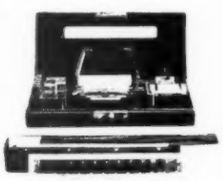


d Low-Pressure Wall-Building Tester

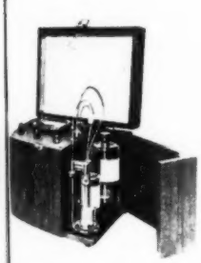
Baroid Stopwatch

Thermometer With Armor

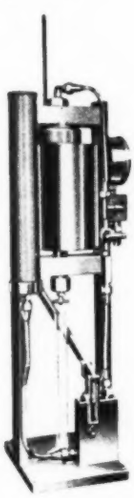
Stormer Viscosimeter



Wulff pH Tester



Beckman pH Meter



Baroid High-Pressure And High-Temperature Wall-Building Tester

THE VALUE of *mud control* has been proved by successful drilling operations to depths undreamed of a few years ago.

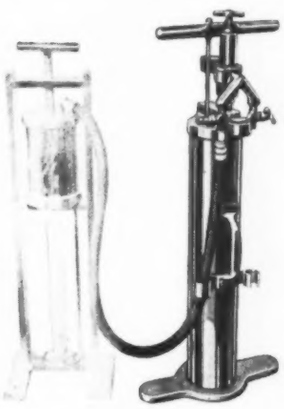
To get this control, in laboratory or oil field, reliable mud-testing equipment is absolutely essential. Such equipment is available at Baroid Sales Department offices in Los Angeles, Tulsa and Houston.

Each unit of Baroid mud-testing equipment has proved its value and efficiency on countless field and laboratory jobs and embodies the same high quality which is characteristic of all Baroid products.

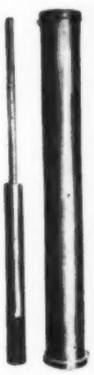
The units illustrated cover a majority of the Baroid products for testing drilling mud. All this equipment is made to A. P. I. standards where such standards exist. Write for literature describing each unit, with directions for its operation.

Welch Triple Beam Balance

Measuring Cup



Baroid Pressure Pump



Mudwate Hydrometer

Hamilton Beach Mixer

Marsh Funnel Viscosimeter

Tyler Screens

Baroid Field Kit For Mud-Testing Equipment

BAROID PRODUCTS

BAROID—Extra-Heavy Drilling Mud. • AQUAGEL—Trouble-Proof Colloidal Drilling Mud. • STABILITE—An Improved Chemical Mud Thinner. • BAROCO—An Economical, Salt Water-Resisting Drilling Clay. • FIBROTEX—For Preventing or Regaining Lost Circulaton. • DISPERSO—For Reconditioning Cement Cut Muds. • AQUAGEL for CEMENT—For setting casing and restoring lost circulation. • ZEOGEL—Special Clay To Be Used As A Suspending Agent When Salt or Salt Water Are Encountered. • TESTING EQUIPMENT—For drilling mud analysis and control

Stocks carried and service engineers available in all active oil fields. Look for this trade mark under "Oil Well Drilling Mud" in your classified telephone directory for our nearest service engineer and distributor

BAROID • AQUAGEL • STABILITE • OIL WELL DRILLING MUD SERVICE

BAROID SALES DEPARTMENT

NATIONAL PIGMENTS & CHEMICAL DIVISION OF
NATIONAL LEAD COMPANY
BAROID SALES OFFICES • LOS ANGELES • TULSA • HOUSTON

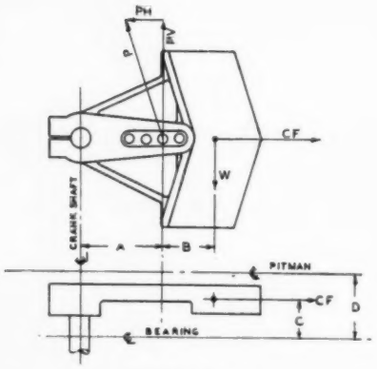


Fig. 14. Crankshaft load diagram with rotary balance

balance is used. Therefore, the values of PH and PV are less and the moments due to these forces are less.

As all these forces are transmitted to the reducer foundation, it follows that the loads imposed on the reducer foundation are greater when a rotary counterbalance is used. In addition to these forces, the centrifugal force created by the rotary counterbalance creates a moment on the reducer that imposes an additional load on the reducer-foundation bolts. The nature of this moment is shown in Fig. 15, and its magnitude is CF multiplied by the distance (A) from the base of the reducer to the centerline of the slow speed shaft. As the direction of the centrifugal force is always along the crank arm, this force tends to lift the reducer at one instant, turn it over at another instant, and drive it into the foundation at another instant. When the rotary counterbalance is used the foundation must be designed to resist all these forces.

It has been shown experimentally by Dr. E. N. Kemler of the Gulf Oil Corporation* that the natural period of torsional vibration of a pumping reducer using a rotary counterbalance may occur in the operating speed range of the prime movers in general use, and that the natural period of torsional vibration of a pumping reducer when used with beam counterbalance is normally above the operating speed range of the prime movers in general use. Prolonged operation of the reducer at a critical speed will cause premature failure of the reducer, and this condition should be avoided.

Beam or pneumatic counterbalance when used alone possesses one disadvantage that will not present itself in an analytical study of the problem, but can be observed in any pumping machine using either type of counterbalance exclusively. This disadvantage is that, at the two points of zero torque, the gears are unloaded and have a tendency to clatter on engine-driven wells, and when the load is reapplied to the gears, considerable impact is developed. This disadvantage can be eliminated by placing sufficient rotating inertia on the crankshaft to keep the gear load acting in the same direction. Rotating inertia at this point also tends to decrease the magnitude of the shock load imposed on the driving mechanism by loose pitman bearings.

The chief objection to a properly designed beam counterbalance system is that it is difficult to adjust the

*Factors Which Influence Pumping Unit Selection, by Dr. E. N. Kemler, A.P.I. meeting, Chicago, 1938.

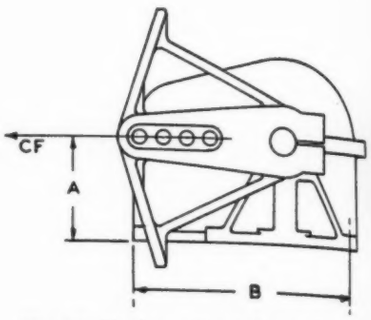


Fig 15. Reducer load due to centrifugal force

amount of counterbalance effect created by it. This and some other disadvantages can be eliminated by using a combination of beam and adjustable rotary counterbalance. If the amount of rotary counterbalance used is sufficient to achieve the minor changes in counterbalance required during the life of a well, this counterbalance system presents many advantages over the system using rotary or beam counterbalance exclusively.

Properly designed beam and pneumatic counterbalance systems impose fewer adverse loads on the elements of the pumping machine and its foundation than does the rotary counterbalance, and they meet all the requirements of an efficient counterbalance. The beam counterbalance, when used with a small amount of adjustable rotary counterbalance, offers the possibility of obtaining the maximum counterbalance efficiency at the lowest initial investment, and therefore, it deserves more consideration than it has received.

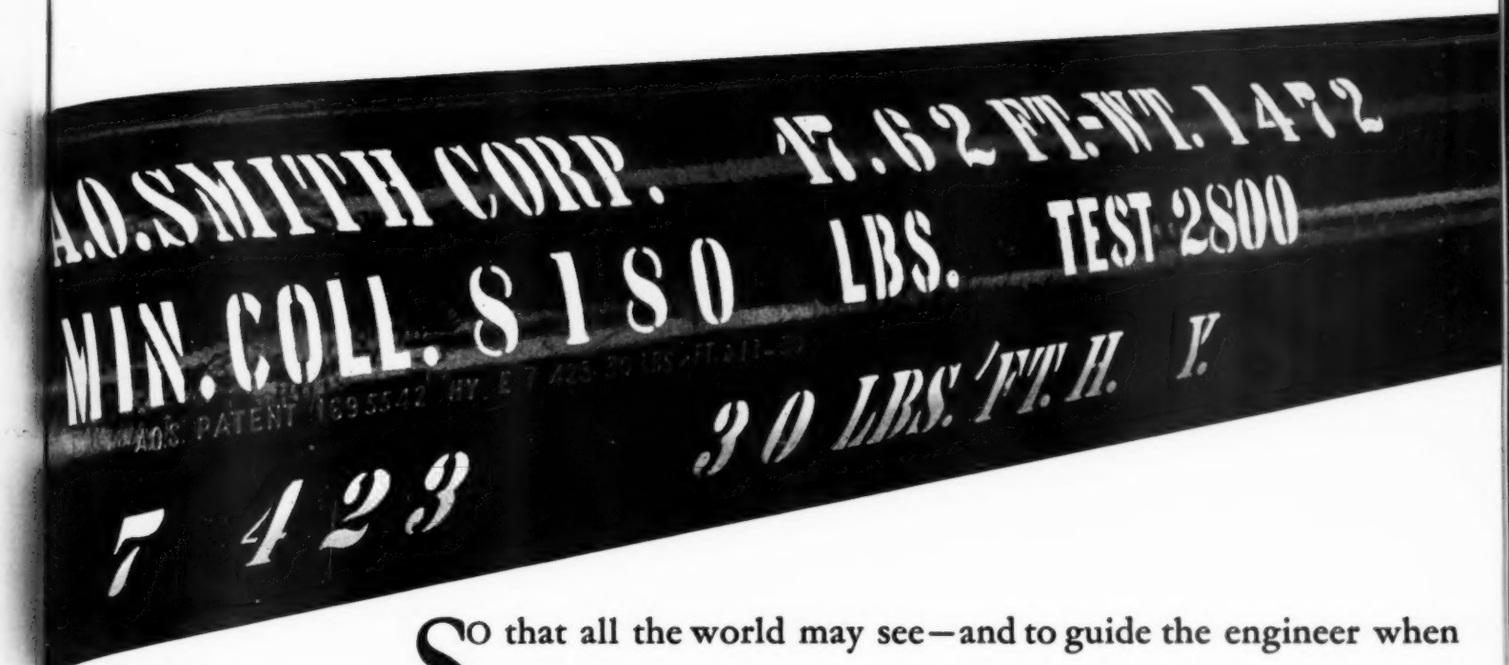
Unusual Safety Record at a Louisiana Oil Refinery Discussed in U. S. Bureau of Mines Bulletin

A REMARKABLE record of progress made in accident prevention at a large petroleum refinery at Baton Rouge, Louisiana, is presented in a report recently issued by the U. S. Bureau of Mines. The report reviews the long record of first-aid training of the employees of the plant and the formation, duties, and activities of the safety department and various safety committees. It also describes safety meetings, first-aid contests, Holmes safety chapters, safety and company publications, safety advertising, bulletin boards, and safety equipment.

As a result of some of these activities three lives have been saved by artificial respiration in the plant and a number of others outside the plant; five employees have been awarded the President's Medal of the National Safety Council, and a number of employees have received certificates of honor from the Joseph A. Holmes Safety Association. In 1938 the Joseph A. Holmes Safety Association awarded a certificate of honor to this plant for having operated through the year 1937 with an accident frequency rate of 3.08 and a severity rate of 0.239 in the performance of 7,453,730 man-hours of work.

Copies of this report, Information Circular 7059, "Safety at the Baton Rouge Refinery, Standard Oil Company of Louisiana," by Eric H. Brown, may be obtained free of charge from the U. S. Bureau of Mines, Washington, D. C .

m Collapse Pressure
gth of Smith Casing



SMITH CASING

So that all the world may see—and to guide the engineer when choosing casing for a given setting depth, the minimum collapse pressure that each length of Smith Casing will withstand is stenciled on that length of casing. This additional service to the users of casing is A. O. Smith's response to the industry's request.

CORPORATION

Milwaukee, Wisconsin

ORPUS CHRISTI • LOS ANGELES • SAN FRANCISCO

PIONEER MANUFACTURERS OF ELECTRIC-WELDED

Casing

Line Pipe • Pressure Vessels

P 934.35

Modern Gasoline Plant Operation Requires Well-Trained Personnel

Maximum efficiency is attained from technological advances only when operators have a thorough knowledge of their jobs

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

By

ROY W. MACHEN
Hamman Exploration Company

THIRTY-SIX years ago, when natural gasoline collected from pipe-line "drips" constituted the bulk of the supply, the man engaged in natural gasoline operation needed to know little more than how to open and close a valve properly. The complexities of a modern natural gasoline plant demand that even the most routine worker, today, have at least a rudimentary knowledge of chemistry and physics as it pertains to natural gases and their various constituents.

The trend toward higher absorption pressures and improved processes for the production of pure compounds, even the development of synthetic by-products, unheard of a few years ago, requires workmen in the natural gasoline plant who have definite skill and knowledge of the work. No longer is it possible to employ an untrained man and charge him with the responsibility of operating a plant after only a few hours of instruction. Efficient plant operation now demands better-trained men who are prepared through knowledge and experience to meet each emergency as it arises. The more complicated modern processing methods require, moreover, that these men have an aptitude for technical work generally.

Many oil companies and some of the oil-producing states through their departments of vocational education have for several years conducted evening classes to provide supervised instruction in details prerequisite to a clear understanding of plant operation. Properly supervised, these classes provide men in the industry the opportunity to either improve or review their knowledge, as the case may be.

Modern equipment used in the manufacture of natural gasoline has been improved rapidly and further improvements are being made constantly. Many companies, recognizing the importance of well-trained personnel as a part of these advances, encourage and aid employees in gaining a thorough knowledge of their jobs in order to keep in step with the process improvements as they are made.

As a direct means of stimulating interest and promoting more efficient operating methods among field and plant workers, the Natural Gasoline Association of America conducts a contest each year in which prizes are awarded for the best and most useful idea submitted.

The employee with ability who improves his knowledge as his company progresses usually finds, when new and better jobs are open, that his effort will be rewarded by promotion in the organization.

Today, competition in the natural gasoline industry is so keen that plant operation must be maintained at the greatest efficiency possible. This objective is best attained when every man in the operating organization is thoroughly versed in the problems involved in his specific job and is awake to every opportunity to improve further his knowledge of the work. As new equipment and processing methods are developed it is each man's responsibility to study and keep himself prepared to cope with the new problems that arise.

ROY W. MACHEN

received a bachelor's degree from Oklahoma City University in 1927—Employed for six and one-half years by the Peppers Gasoline Company as refinery clerk, refinery and gasoline plant chemist, and gas engineer—The last five and one-half years have been spent in the service of various independent refining companies as gas engineer, operator in high-pressure gasoline plants, refinery construction engineer, and superintendent of refinery operations—He is a registered petroleum and natural gas engineer.

A Workman's Knowledge May Be General

It may not be essential that an operator be able to say offhand that the symbol for octane is C_8H_{18}, or that octane is a member of the paraffin series, the type formula of which is C_nH_{2n+2}. It is probably more important to know that the vapor pressure of octane at 100°F. is 0.4 lb. abs. and its critical temperature is 566°F. He should be familiar, however, with the names of the usual constituents of natural gas and with their respective properties. Such terms as specific gravity, molecular weight, boiling point,

(Continued on Page 153)

(Continued from Page 150)

endpoint, pentanes and heavier, g.p.m. as related to oil circulation and recoverable gasoline, B.t.u., etc., should have a very definite meaning to him. It is only through knowledge of this kind that plant operation will be entirely intelligible to him.

The terms reflux, vapor pressure, top temperatures, base temperatures, inlet pressure, inlet and residue content, stabilization, butane, propane, and many other phrases and names are a part of the average operator's daily conversation. He will usually have some idea of their meaning but too often his conception of their real significance in plant operation will be vague. Most efficient operation will inevitably follow if each man knows the reason *why* these terms are an important part of his routine duties. The coördination and timing of various operations that is so essential in the efficient plant may be obtained with satisfying results only through intelligent performance on the part of each operator.

An increase or decrease in either dephlegmator or still top temperature —an increase or decrease in the amount either of steam used for agitating or of condensation pressure will change the physical properties of the raw gasoline. It is not essential that the operator know the theory of why these changes will affect the product, but it is necessary for him to know, at least, the rules that govern these changes in order that he may understand and control more efficiently the plant operation.

The operator must know something of the mechanics of distillation, absorption, heat exchange, condensation, evaporation, and stabilization before he can do his work properly. It is not necessary that he be an expert, but he must have some idea of the processing phenomena that occur continuously inside the equipment before he is able to meet intelligently the changing conditions that arise constantly while he is on duty.

Every plant operator should be conversant with the safety practices that will protect his life and avoid damage to the equipment. A thorough knowledge of controls and regulators used in the plant and, preferably, an understanding of the adjustment of these instruments will aid materially in assuring safe and efficient working conditions.

Proper maintenance and repair of plant machinery and equipment such as compressors, pumps, boilers, pressure vessels, valves, and piping are important factors in plant operation. The ability to perform properly work of this kind greatly enhances the employee's value.

It is a long stride from the "drip" of 1903 to the "poly" plants and absorption plants of 1939 operating at pressures exceeding 1000 lb. in conjunction with recycling and gas injection units for reservoir maintenance of pressure. Important though advances in processing technology have been, of equal if not greater importance is the need for creating a better-informed personnel to operate these more complicated processes.

Changes Announced in Methods of Publishing A.S.T.M. Standards

IMPORTANT modifications are to be made, according to an announcement from the headquarters of the American Society for Testing Materials, in the methods of publishing the Society's standard specifications and tests. These changes are to become effective November, 1939. The major change is to combine the Book of Standards (issued triennially) and the Book of Tentative Standards (issued annually). These changes, which embody numerous advantages, are necessary because of the great growth of A.S.T.M. standardization work, it is stated.

The 870 A.S.T.M. standards are in widespread use in many branches of the petroleum industry. Each is available, and will continue to be so in separate pamphlet form. The standards also have been issued in book form triennially, and annually in a volume giving the so-called tentative standards and tests.

The new method of publication will be to issue the standards and tentative standards collectively in one triennial publication, divided into three parts: Part 1, Metals; Part 2, Non-Metallic Materials — Constructional; and Part 3, Non-Metallic Materials—General. Publication of new and revised tentative standards in the annual *Proceedings*, Part 1, will be discontinued; the *Proceedings* including both committee reports and papers (about 1300 pages double-column format) will be bound in one volume. The publication of the annual Book of Tentative Standards will be discontinued entirely. (The November, 1938, edition is thus the last one to be issued.)

In the two years between triennial publication of the new book, supplements to each of the three parts will be issued, containing revisions and new or revised standards and tentative standards for that year. As these books will be appreciably larger than the present supplements and will have permanent reference value, they will be bound in cloth. The volume on Methods of Chemical Analysis of Metals published in 1936 will be continued as a separate publication.

This new plan provides that the three parts of the 1939 Book of A.S.T.M. Standards and Tentative Standards shall be made up as follows:

Part 1. Metals — Ferrous and nonferrous metals (all A and B and some E serial designations) except methods of chemical analysis. General testing methods (E serial designations).

Part 2. Non-Metallic Materials—Constructional.—Cementitious materials, concrete and aggregates, masonry building units, ceramics, pipe and tile, thermal insulating materials (all C serial designations). Timber and timber preservatives, paints, varnishes and lacquers, road materials, waterproofing and roofing materials, and soils (certain D serial designations). General testing methods, thermometers (E serial designations).

Part 3. Non-Metallic Materials—General.—Fuels, petroleum products, electrical insulating materials, rubber, textiles, soaps and detergents, paper, plastics, water (remainder of D serial designations). General testing methods, thermometers (E serial designations).

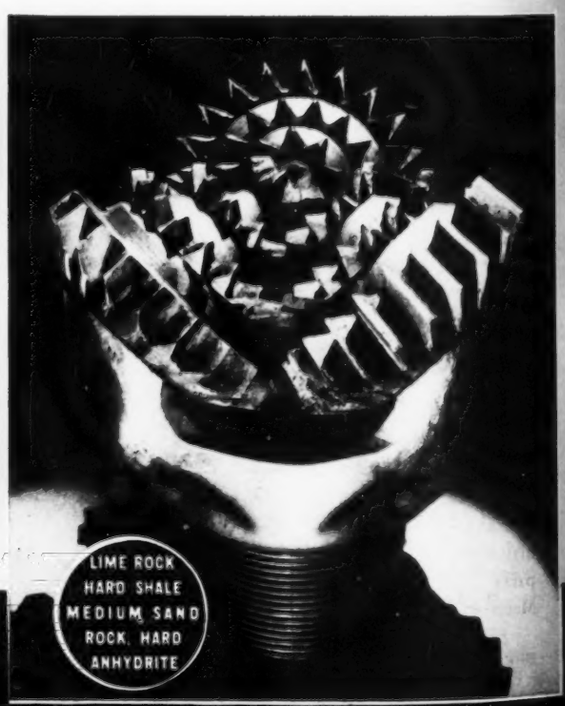
Further details of the publication plan can be obtained from the headquarters of the Society, Philadelphia, Pennsylvania, including sales prices that have been established for the new Book of Standards, 1940-41 Supplements, and the annual *Proceedings*.

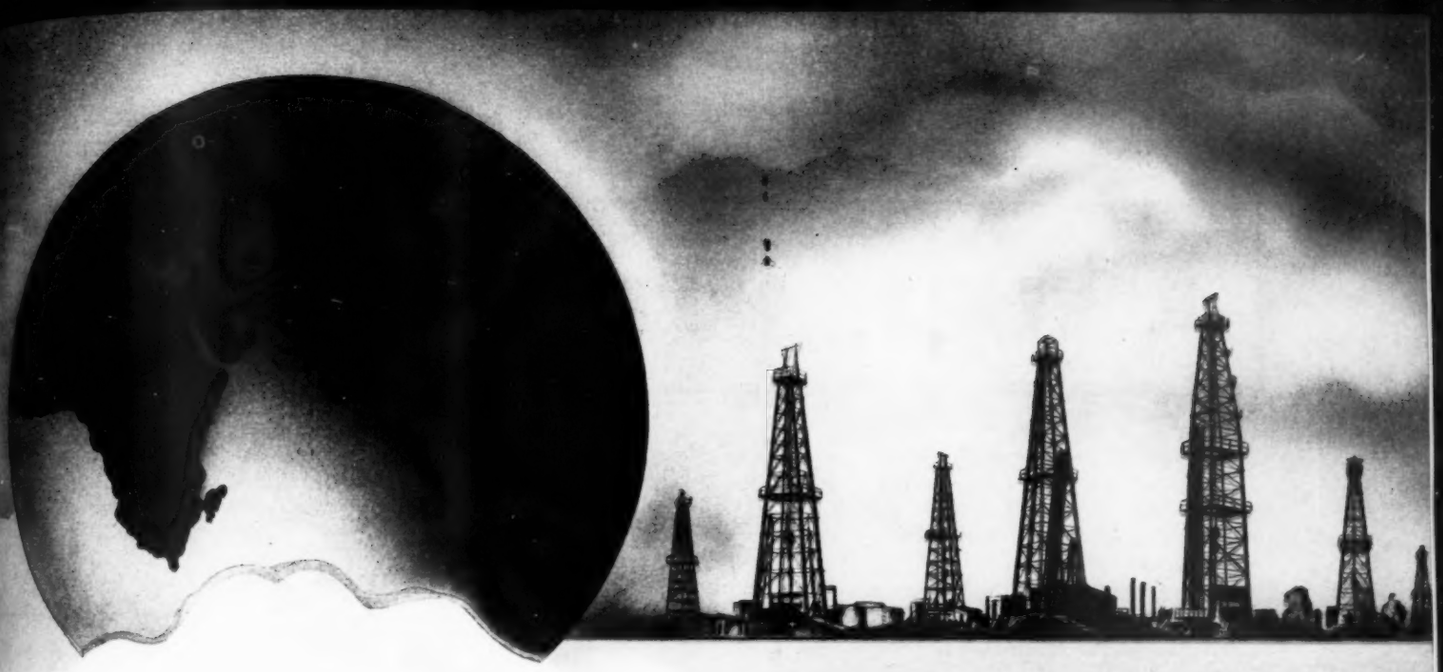
Regardless of Field, Formation or Country..

HUGHES ROCK BITS *Lead* in Making

STRAIGHT HOLE because: the basic three-cone design provides balanced drilling operation that is smooth running and free cutting . . . 50% more teeth on bottom at outer portion of hole, providing stabilized cutting . . .

FAST HOLE because: they are specially designed for specific formation ranges . . . no stationary parts on bottom to invite balling-up . . . self-cleaning . . . 50% more teeth on bottom at outer portion of hole where greater part of formation is removed . . . all teeth hard-faced with Hughesite . . . sturdy bearings and rugged construction permit running with plenty of weight.





STRAIGHT, FAST, FULL GAUGE HOLE !

FULL GAUGE HOLE because: there is 50% more rolling contact on wall of hole to preserve gauge . . . all gauge surfaces hard-faced with Hughesite to insure long life . . . geometry of construction keeps cones at full gauge even as wear progresses . . .

FOR GREATER FOOTAGE OF FAST, STRAIGHT
FULL GAUGE HOLE, SPECIFY HUGHES.

HUGHES TOOL CO., HOUSTON, TEXAS, U.S.A.

LAUGH WITH BARNEY

Another Ice Man Story

Jerry, the ice man, says he was late delivering ice on the third floor the other day because he got a little behind on the second floor.

* * *

Employer: Now I hope you thoroughly understand the importance of punctuation.

New Stenog: Oh, yes, indeed; I always get to work on time.

* * *

Q: What has become of the merchant who used to give his customer a cigar when he paid his account in full?

A: What has become of the customer who used to pay his account in full?

* * *

Their cars having collided, Jock and Pat were surveying the situation. Jock offered Pat a drink from his bottle. Pat drank and Jock returned the bottle to his pocket.

"Thank ye," said Pat, "but aren't ye going to have a nip yourself?"

"Aye," replied Jock, "but not until the police have been here!"

* * *

Rastus (fixing flat tire): This ??!&? tire sticks on de wheel like somebody done glued it on.

Parson (passing by): Here, here, Rastus, you mustn't cuss like that. Don't you know that a prayer to the Almighty will bring you better luck?

Rastus reverently knelt in prayer.

Rastus: You're right, Pahson, de tire done fell right off.

Parson: Well I'll be damned!

* * *

On a quiz given at a leading university recently one of the questions was: "Name two ancient sports." A freshman wrote: "Anthony and Cleopatra."

* * *

Fifty-nine years he practiced medicine, being responsible for most of the babies born in the community.—*Pomeroy (O.) Democrat.*

* * *

Legal Problem

There were three men, A, B and P.

P called B, who was a grocer, and ordered a case of beer. B misunderstood the order and delivered the case of beer to A. Now is A liable to P?

Husband: We had a drinking contest today.

Wife: Who won second?

* * *

Doctor: Well, madam, what seems to be the matter?

Blonde: Pains in my arms so I can hardly lift them over my head—and it's the same with my legs.

* * *

Then there's the story about the Scotchman who spanked his children and put them out in the flower bed to cry.

* * *

Betty: Do you have any green lipsticks?"

Drug Store Clerk: Green lipsticks?

Betty: Yes, a railroad man is going to call on me tonight.

* * *

"Sir, I believe you are trying to kiss me!"

"Well, now that you know, suppose we quit assaulting each other and cooperate a little."

* * *

Young man, visiting summer training camp (to good looking maid): Who's Major around here?

Maid (demurely): No one—yet.

* * *

"Here's a man trades his wife for a 1936 model car. What do you think of that?"

"I hardly know. What model was she?"

* * *

It happened in Seattle's largest department store during a rush. The elevator was jammed, and the cables groaned.

The elevator rose slowly, and as it neared the third floor, a piercing scream caused the operator to stop the car midway. All eyes were focused on a large woman in a short seal jacket, who wore an injured expression. A small boy, not yet of school age, stood directly behind her.

"I did it," he announced truculently, "It was in my face, so I bit it."

* * *

Somebody told Tilly, the office stenog, that a chiropractor could cure her neuritis. Now Tilly says that "a chiropractor is a guy who gets paid for what an ordinary guy gets slapped for."

Engineers are often baffled by the fact that some of the girls with streamlined figures offer the most resistance.

* * *

Mother: Daughter, didn't I tell you not to let that strange man come over to your apartment last night? You know it's things like that that cause me to worry.

Daughter: Don't be so ridiculous, mother. I went over to his apartment. Now let HIS mother worry.

* * *

The cub reporter who was assigned to cover the class plays of the high school came in for his share of literary fame when the following turned up in his write-up:

"The auditorium was filled with expectant mothers, eagerly awaiting the appearance of their offspring."

* * *

The modern optimist is the fellow who thinks his wife has quit cigarettes when he starts finding cigar butts around the house.

* * *

Vacations are simpler nowadays. A man has a wife to tell him where to go, and an employer to tell him when, so all that is needed is someone to tell him how.

* * *

Judge: You're fined twenty-five dollars and costs.

Woman Shopper: I'm sorry, Judge —but that's a little more than I care to pay.

* * *

One of our salesmen called on a prospect, and was finally admitted. "You should feel flattered," said the prospect, "I've refused to see seven salesmen today."

"Yeah, I know," said the salesman, "I'm them."

* * *

Men At Work

A self-styled reformer was watching a trench being dug by modern methods. He said to the superintendent:

"This machine has taken jobs from scores of men. Why don't you junk that machine and put 100 men in that ditch with shovels?"

The superintendent promptly retorted: "Or better, still, why not put a thousand men in there with teaspoons?"

Running Tour
WITH MEN IN THE INDUSTRY

GORDON F. HESS, formerly assistant manager of sales of the Alloy Steel Division of Republic Steel Corporation in Massillon, Ohio, was appointed district sales manager of the Houston District, effective June 1st, it is announced by **N. J. CLARKE,** vice-president in charge of sales. Hess entered the steel business in 1917 in the metallurgical department of the Central Steel Company, which later became Central Alloy and is today a part of Republic. His first major promotion was to assistant superintendent of the heat-treating and cold-drawing department of Central Steel. Subsequently he became superintendent of that department and remained in that capacity until 1922 when he was transferred to the sales division. In 1931 he was made assistant manager of sales of the Alloy Steel Division.

T. N. ST. HILL, president of the Petroleum Rectifying Company of California, left Los Angeles recently for an extended visit to Chicago, New York, and other cities on company business. Returning by the southern route, he is scheduled to spend some time at the company's Gulf Coast headquarters in Houston, Texas, before returning to his office.

C. F. WHALEY, who has been made special representative of the Hydril Company of Texas. His headquarters are in Houston.

JUAN A. BENNESAR, an official with the Argentine Government in petroleum operations, is in Los Angeles, California.

L. F. STATTON, who recently accepted a position as division manager of the Arrow Drilling Company. His headquarters are at the company's new office in Houston, Texas. Statton previously was assistant to E. P. Halliburton, president of the Halliburton Oil Producing Company.

DR. GERALD MARK RASSWEILER and **DR. LLOYD WITHROW,** scientists in the research division, General Motors Corporation, Detroit, Michigan, have been awarded the Horning Memorial Award of the Society of Automotive Engineers for a paper, "Motion Pictures of Engine Flames Correlated With Pressure Cards." The picture and paper were presented by the authors during the annual meeting of the Society, January 14, 1938, in Detroit.

HARRY F. STANLEY, managing director of Drilling and Petroleum Engineering Operations, Ltd., of Trinidad, is on vacation in Los Angeles, California.

G. M. STICKELL has been advanced from assistant sales manager to sales manager of the Landis Machine Company, Waynesboro, Pennsylvania.

ROBERT W. HARRISON, Houston, Texas, has resigned as division petroleum engineer for the Continental Oil Company to become affiliated with Parker, Foran, Knode and Boatright, consulting petroleum engineers. He is stationed at the recently opened office of the company in Calgary, Alberta, Canada.

GENE McINTYRE, Los Angeles, California, who for several years has devoted his efforts entirely to the sale of Victaulic flexible pipe couplings, is now enlarging the scope of his sales agency. He will in the future handle equipment of the following manufacturers: Rector Well Equipment Company, Fort Worth, Texas; W-K-M Company, Houston, Texas; Crutcher-Rolfs-Cummings, Houston, Texas; Naylor Pipe Company, Chicago, Illinois; The Inferno Company, Shreveport, Louisiana, and Victaulic Company of America, New York City.

PAUL CLARK, president of Clark Bros. Company and vice-president of Dresser Manufacturing Company, was a visitor at the convention of the Natural Gas Section of the American Gas Association, in Tulsa, and also attended the American Petroleum Institute meeting in New Orleans. He was accompanied by **J. B. O'CONNOR,** vice-president and sales director of Clark Bros. Company and a director of Dresser Manufacturing Company, and they made a tour of the Mid-Continent oil fields before returning to the East.

H. C. BEAVER, president, Worthington Pump and Machinery Corporation, Harrison, New Jersey, announces that **EDWIN J. SCHWANHAUSSER** has been elected a vice-president of the company. Schwanhausser's connection with Worthington dates from 1915, at the time of his graduation from Stevens Institute of Technology. Assigned to the Harrison, New Jersey, Works, he served in a number of capacities, attaining the position of assistant works manager in 1927. In 1929 he was transferred to the Buffalo, New York, Works as works manager, which position he now holds.

F. C. LAURIE, vice-president and general manager of the Lago Petroleum Corporation in Maracaibo, Venezuela, has been promoted to the executive staff of the Producing Department of the Standard Oil Company of New Jersey and transferred to New York City. **J. A. CLARK** becomes vice-president and general manager at Maracaibo. **G. M. KNEBEL** has been promoted from the managership at Caripito in eastern Venezuela to the executive staff and will have his headquarters at Caracas. His duty will be to coordinate all exploration activities of the company in Venezuela. **H. M. HOBERG** also has been transferred from Caripito to Caracas where he will replace **R. C. WELLS** as executive assistant to the president. Wells has been sent to Buenos Aires to join the executive staff of the Standard Oil Company, S.A., Argentina. To replace Knebel, **A. T. PROUDFIT** has been made manager of the Standard Oil Company of Venezuela in eastern and central Venezuela and has his headquarters at Caripito.

F. C. LAURIE

J. A. CLARK

G. M. KNEBEL

H. M. HOBERG

A. T. PROUDFIT

OSCAR MEYER, who has completed 50 years of continuous service with the Pittsburgh Equitable Meter Company, was given a luncheon recently at the Penn Lincoln Hotel, Wilkinsburg, Pennsylvania. The guest list included fellow employees and officials of the company whose years of service totaled 665, an average of 30 years. Three of the group, **OSCAR MEYER, H. C. CHRISMAN,** and **JOSEPH KLINE,** have a total service record of 150 years.

A. M. MARTINI, who for the last 13 years has occupied various positions with the Bell Oil and Gas Company, recently as general manager of the Bell General Pipe Line Company of East Texas, has joined the Finston and Company organization as vice-president in charge of operations in Texas, Louisiana, and New Mexico. Finston and Company have their headquarters in Tulsa, Oklahoma.

GRANT W. CORBY, general manager for Far East Oil Development Corporation of the Philippine Islands, recently left Los Angeles, California, to return to Manila. **MARTIN O. LANDERS,** drilling superintendent for the same company, also left recently for Manila.

MERLE DEMPSEY, tool pusher for the Magnolia Petroleum Company, has been transferred from the Iatan district to the Lea, New Mexico, district.

F. ERICH BRUHN, who for the last three and a half years has devoted his time to the sales of Superior Diesel and gas engines for the National Supply Company, having his headquarters in Midland, Texas, is now associated with the Equipment Supply Company at El Paso, Texas. Bruhn will have charge of the sales of General Motors Diesel engines in West Texas, New Mexico, and Old Mexico for the Equipment Supply Company, who are distributors for these engines.

G. S. WILKIE, tool pusher for the Magnolia Petroleum Company, has accepted a position with the Socony-Vacuum Oil Company, of which Magnolia is a subsidiary, and will be sent to Colombia, South America. He has been stationed in the Rodessa, Louisiana, district.

S. E. CHARLEBOIS, formerly tool pusher for Caribbean Petroleum Company, has recovered from a recent illness and at present is in Anaheim, California.

LEVI H. DUNCAN, retired sales manager of the Pittsburgh Equitable Meter Company, died recently at the home of his son, L. C. Duncan, in Monroe, Louisiana, as the result of a cerebral hemorrhage. He was 78 years old. Duncan was first employed at the age of 18 as a machinist's apprentice by the Pittsburgh Supply Company. This firm later became the Equitable Meter Company, which in turn merged with the Pittsburgh Meter Company, to form the present Pittsburgh Equitable Meter Company.

A. J. RUTHVEN-MURRAY, president of Kern (Trinidad) Oilfields, Ltd., spent some time at the Los Angeles, California, offices of Kern River Oil Company, before returning to Trinidad. Previously he had visited the Mid-Continent area.

KUHN CALVER, field superintendent of the Burmah Oil Company, who, with Mrs. Calver, has been in California for several months on leave, recently returned to Burma.

BUCK WEAVER has left for Peru, where he will be employed as driller on Compania de Petroleo Ganzo wells in the new field recently discovered at the head waters of the Amazon in Peru.

ERNEST HAIER, engineer for Romano-Americana and having headquarters at Teleajen, Roumania, is now in California studying American equipment and methods. With him is **R. A. STEFANESCU.**

DR. H. HUGEL, exploitation engineer for Astra Romana, recently left Los Angeles, California, for Campina, Roumania. He has been in California since February studying operating methods and equipment.

R. G. BENNETT has left Los Angeles, California, for San Francisco and from there will return to Trinidad via Miami. Bennett is senior driller with Trinidad Leaseholds, Ltd., and has been combining a vacation with an inspection of new equipment as used in California operations.

C. H. FEWELL recently sailed for Burma after an extended stay in California. Upon arrival at his destination he will work as driller for the Burmah Oil Company.

W. A. STEWMAN, driller with Bahrein Petroleum Company, is spending a few days in Los Angeles, California. He and Mrs. Stewman will go to San Francisco, California, and from there will return to Bahrein Island.

ALEXANDER PARMULA, field engineer for Colombia Company, having his headquarters at Moreni, Roumania, has been in California on business. He will soon leave for the Mid-Continent area and from there will return to Roumania.

J. A. SMITS, equipment standardization engineer for Bataafsche Petroleum Maatschappij, left California recently for the Mid-Continent where he will spend the next few months and then return to the Netherlands East Indies. He is accompanied by Mrs. Smits and their daughter.

F. W. FLOYD, vice-president and manager of the Production Department of The Carter Oil Company, was transferred, effective June 15, to the Standard Oil Company of Venezuela, and will be stationed in Caracas, Venezuela. **R. L. CLIFTON,** general superintendent and assistant to Floyd, has assumed the latter's duties.

F. W. FLOYD

H. M. HASELTINE, assistant to the president of The Guiberson Corporation, has returned to his office in Dallas, Texas, after an eastern trip during which he made a survey of general conditions and sales prospects in the Illinois, Michigan, and Pennsylvania oil fields.

C. R. BICKEL has been made Kansas division manager by the Shell Oil Company and transferred from Tulsa, Oklahoma, to Wichita, Kansas. He succeeds **H. E. ZOELLER,** who is now with the Derby Oil Company as vice-president and general manager.

LESTER G. METCALFE recently was made manager of marine operations of the Union Oil Company of California. He succeeds **WILLIAM GROUNDWATER,** resigned.

C. F. NICKLOS, superintendent of the Rocky Mountain division of The Texas Company, has been transferred from Craig, Colorado, to Denver where the company maintains its headquarters.

HARVEY WHITAKER, manager of the Bridwell Oil Company at Mattoon, Illinois, has been transferred to Wichita Falls, Texas.

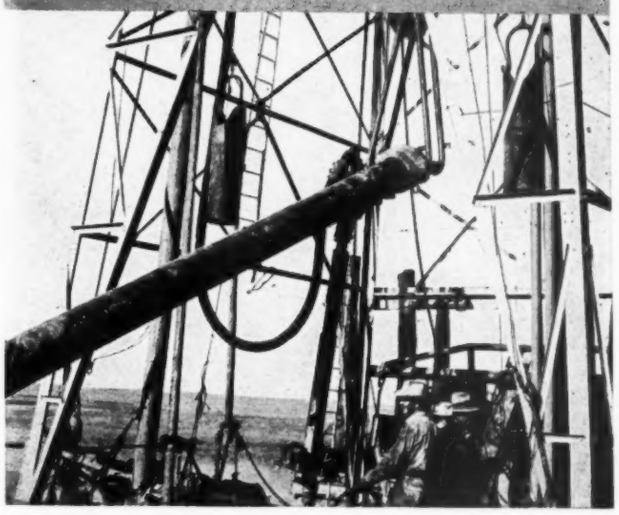
L. P. ST. CLAIR has resigned as chairman of the board of directors of the Union Oil Company. He will remain a director but retire from active management of the company.

GEORGE T. YOST, superintendent of the Pure Oil Company's Muskogee, Oklahoma, refinery, has joined the staff of the Phillips Petroleum Company as process engineer. He is stationed at Borger, Texas.

JOHN M. MADISON, Shreveport, Louisiana, has been elected president of the Atlas Pipeline Corporation to succeed **E. R. MEINERT,** resigned.

J. W. POOLE has been made assistant manager of manufacturing of the Lion Oil Refining Company, El Dorado, Arkansas. Poole has been a consultant in petroleum technology, having his headquarters in New York City.

SPEED THE JOB
At Less Cost
WITH ARMCO CASING



• You save both time and money with Armco Slip-Joint Surface Casing. It is strong yet light in weight, making it easy to handle and set. Assembly is simple as the ends line up quickly without using clamps and there is no need of costly fittings for slips, tongs or elevators.

Savings often run as high as 37% because Armco Casing is available in diameters and weights to exactly meet your needs. Then too, you also eliminate the extra expense of threaded ends and collars that are cemented-in and never reclaimed.

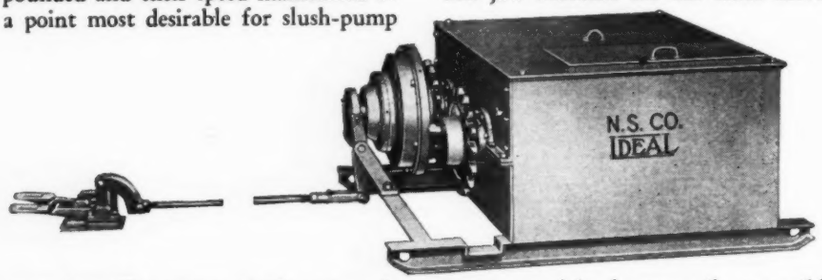
Immediate delivery of Armco Slip-Joint Surface Casing can be made throughout the Mid-Continent area and Illinois from stocks maintained by our distributor. Phone, write or wire your needs to their nearest store, or to The American Rolling Mill Company, Pipe Sales Div., Middletown, Ohio; 538 Mayo Bldg., Tulsa, Okla.; 3500 Maury St., Houston, Texas.

ARMCO
SURFACE CASING
Distributed By
NATIONAL TANK COMPANY
Tulsa, Oklahoma, and Branches

MACHINERY and EQUIPMENT

"DR" Transmission

THE National Supply Company, Toledo, Ohio, now presents the Type "DR" Transmission—a self-contained speed reducer for driving a rotary machine in connection with an internal combustion engine rotary rig drive. It is of the chain-drive type and provides three selective speeds to the rotary table for drilling and coring, thus permitting the engines to be compounded and their speed maintained at a point most desirable for slush-pump



operation. The transmission is positioned between the drawworks and the rotary machine, and is driven by the regular rotary drive of the drawworks. This arrangement permits a low chain drive to the rotary machine, and as the "DR" Transmission is a compact unit, there is no interference with the racking of pipe in front of the drawworks, the makers state.

Smooth power engagements are provided by a double disk friction clutch. The foot pedal control of this clutch can be conveniently placed at the driller's position.

The input and output shafts are $5\frac{3}{16}$ in. and 5½ in. in diameter, respectively, and are mounted on self-aligning roller bearings. The chain drives have 1¾-in. pitch double strand chain and sprockets with machine-cut teeth. The jaw clutches for the three drives are operated by levers easily accessible through a door in the top of the housing. The input and output sprockets are for No. 3 A.P.I. chain and the former is bolted to the spider of the friction clutch and mounted on a roller bearing.

The transmission drives are completely enclosed in an oil-tight housing. Long life for the bearings, chains, sprockets, and clutch shifter fingers is assured by an automatic lubrication system, it is stated.

The Type "DR" Transmission has three speed ratios: 2 to 1, 1.31 to 1, and 1.05 to 1, and has a 200-hp. working capacity.

Testing Drill Pipe

AN extension of its policy of 100 percent inspection of oil country goods has been put into effect by the Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania. Two new procedures involving a recently developed instrument, the Tube-wall-scope, and a new application of the Magnaflux method are now being used to inspect, during production, both the interior and exterior surfaces of every length of J & L Blue Ribbon seamless steel integral joint drill pipe.

The Tube-wall-scope provides an accurate, scientific method of inspecting the inside of tubular goods for defects that might result eventually in pipe failures in the field.

The Tube-wall-scope is a precision instrument resembling an exceptionally long telescope. It is equipped with an adjustable focus eyepiece at one end and a series of special lenses, reflectors, and a specially designed high-powered light at the other. The lenses are arranged to permit the operator to inspect the complete 360 deg. of circumference inside any tubular product as the Tube-wall-scope is pushed slowly through the pipe. Guide baskets mounted on the barrel serve to center the instrument in the pipe.

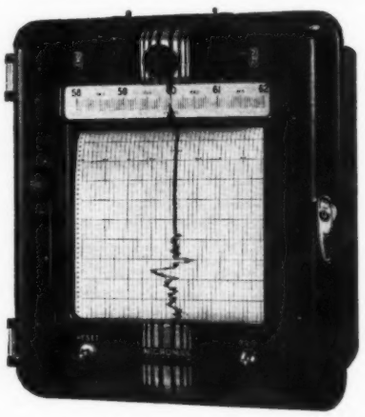
As the Tube-wall-scope magnifies the size of the image of a defect, an experienced inspector can quickly recognize any flaw as a possible source of failure and by calibrations on the instrument barrel can then readily determine the location of a defect.

Every length of integral joint drill pipe now being produced by Jones & Laughlin is also subjected to the Magnaflux test. This drill pipe eliminates the conventional type tool joint by having a forged upset tool joint integral with the pipe itself. The magnaflux test is applied to the exterior of this forged upset to detect defects not visible to the eye.

This test consists of placing the pipe in a magnetic field and then sprinkling the pipe with a metallic powder or solution. Even though not otherwise visible, any defect will immediately become apparent as the red powder is attracted by magnetic action to a flaw and collects there.

Micromax Frequency Controller, Industrial Type

A NEW Micromax frequency controller, industrial type, now provides the isolated generating plant with automatic control of frequency that



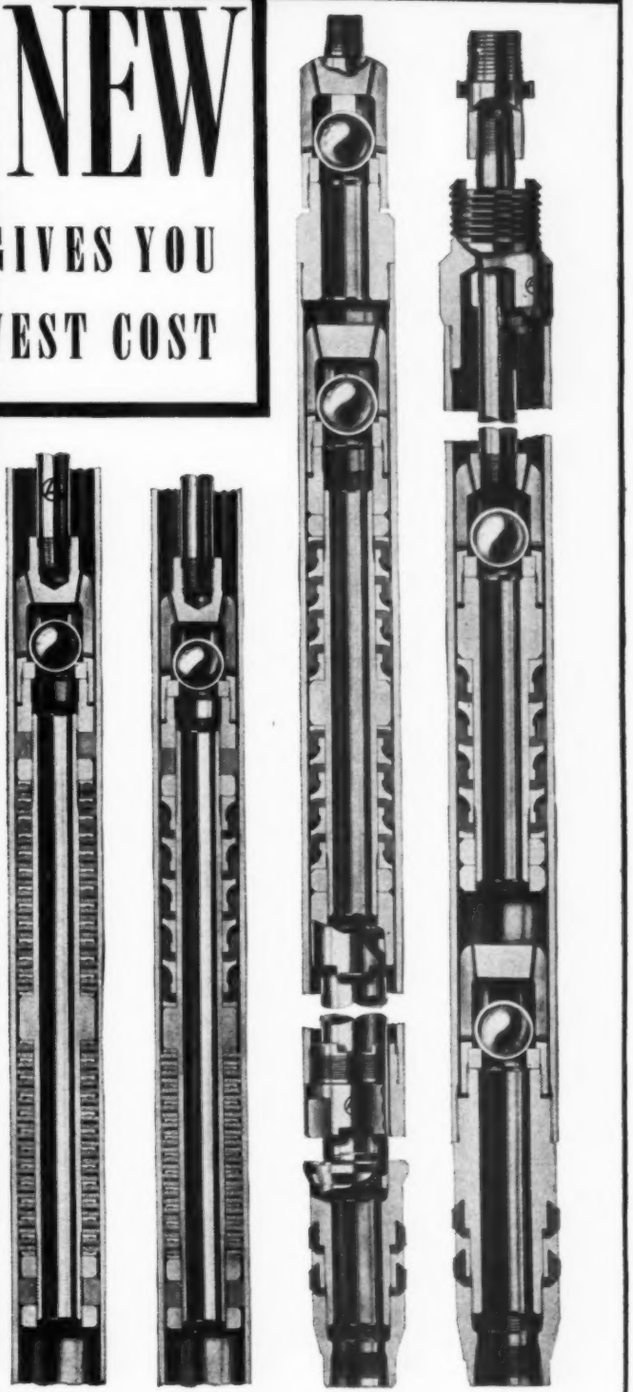
heretofore has been thought feasible only for large central stations on interconnected systems.

In one compact case is combined the well-known Micromax frequency indicator and recorder with an automatic controller, a simple, relatively inexpensive arrangement that omits the refinements necessary for large central stations on interconnected systems.

To receive a copy of the new 8-page booklet describing this new controller, write to Leeds and Northrup Company, 4934 Stenton Avenue, Philadelphia, Pennsylvania. Ask for Catalog N-56-161(1), "Micromax Frequency Controller—Industrial Type."

NEW

THIS AXELSON KUP-PAK PUMP GIVES YOU QUALITY PERFORMANCE AT LOWEST COST



Axelson Kup-Pak Pumps are designed and built to give quality pump performance at lowest equipment cost in those fields where production is restricted or does not warrant the use of other type or metal-to-metal pumps. Accurately molded cups are positioned on the plunger to operate in the cold-drawn, seamless steel barrel which is actually honed in a special honing machine. Made in both stationary and traveling barrel types in all standard lengths and diameters, the plunger construction can be altered to combine cups and neoprene rings, or to use neoprene rings only. They can be installed in the top of an old barrel or with a seating nipple in the well.

Axelson Kup-Pak Pumps are ideally suited for wells in which production can be handled with packing or cup plungers. Write for Bulletin on Kup-Pak Pumps.

Axelson builds three complete lines of Deep Well Plunger Pumps—Standard Liner Pumps (T. S. L. & R. S. L.), Sure-Seal Pumps, Kup-Pak Pumps—to meet every pumping condition and price requirement.

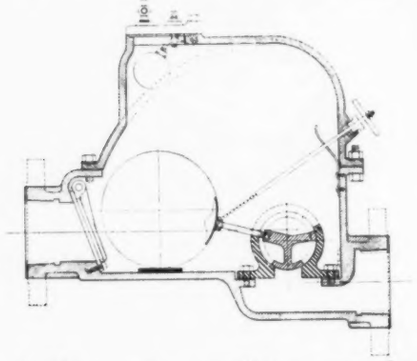
AXELSON

AXELSON MANUFACTURING CO.

P.O. Box 98, Vernon Station, Los Angeles • St. Louis • 50 Church St., New York • Tulsa • *Mid-Continent and Eastern Distributor:* Frick-Reid Supply Corp. • *Rocky Mountain Distributor:* Great Northern Tool & Supply Co. • *Foreign Representatives:* "COSMOS" Soc. in Nume Colectiv, Bucharest, Roumania • *Direct Factory Representative,* Bucharest, Roumania • Industrial Agencies, Ltd., San Fernando, Trinidad, British West Indies • *Factory Representative,* Maracaibo, Venezuela • Armco International Corp., Buenos Aires, Argentina

Carlos Valve

WESTCOTT AND GREIS, Inc., Division of American Meter Company, Tulsa, Oklahoma, are offering to the pipe-line industry the Carlos Pipe-Line Shut-Off Valve for oil pipeline gravity systems. The valve is fully automatic. It automatically shuts-off the ground line the instant oil flow is exhausted, it reopens automatically



should operating conditions cause the valve to close before the tanks are empty, and it automatically adjusts to any volume of flow to the maximum capacity of the ground line.

The Carlos Valve is installed on the ground line from each battery of tanks. When the float ball is at rest, the outlet is closed, but when oil is admitted through the inlet, the ball immediately rises, opening the outlet valve, and when the float ball reaches a nearly upright position the outlet valve is opened to the full capacity of the ground line.

Any gas or air entering the Carlos Valve collects in the top of the valve chamber, which is open to the outer air through the bleeder valve until such time as the oil level in the chamber rises nearly to top of chamber, when it automatically closes the bleeder valve by operating the small float on this valve. This valve, during flow of oil, thus automatically maintains a small gas and air pocket at top of valve chamber, releasing surplus air or gas whenever the oil level falls. The restriction of orifice capacity caused by lowering of the ball float lets pressure build up from the tank or tanks.

When oil flow is insufficient to tax the capacity of the ground line, the level in the valve chamber falls, lowering the float ball and automatically adjusting the outlet opening at the point where it will just accommodate the available flow. Thus the flow is steady.

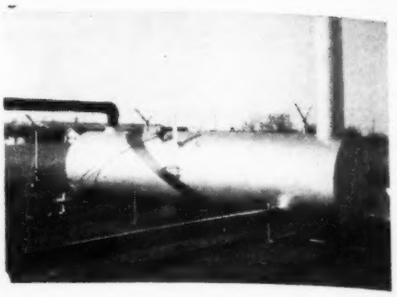
The back-up check valve on the inlet prevents any backing-up of oil into tanks, thus eliminating danger of a tank on a low level being caused to overflow by oil backing-up from higher tank batteries.

The two check valves seen at extreme lower right-hand corner of the valve chamber in the illustration are two opposed pressure-relief valves between the valve chamber and the ground line, provided to eliminate danger of excess pressure in the Carlos Valve, when the valve and tank stops are closed.

Horizontal Fire Tube Heater

DESIGNED to minimize the possibilities of burnouts, the Horizontal Fire Tube Heater is the newest piece of heating equipment designed by Black, Sivalls and Bryson, Inc., Oklahoma City, Oklahoma.

The B. S. & B. Temperature Controller makes the heater fully automatic and maintains high efficiency,



the makers state. Absence of flat heating surfaces, a large settling space, and large combustion space result in greater protection against burnouts, it is asserted.

Erection work is reduced to a minimum and service work can be done quickly and easily, it is pointed out.

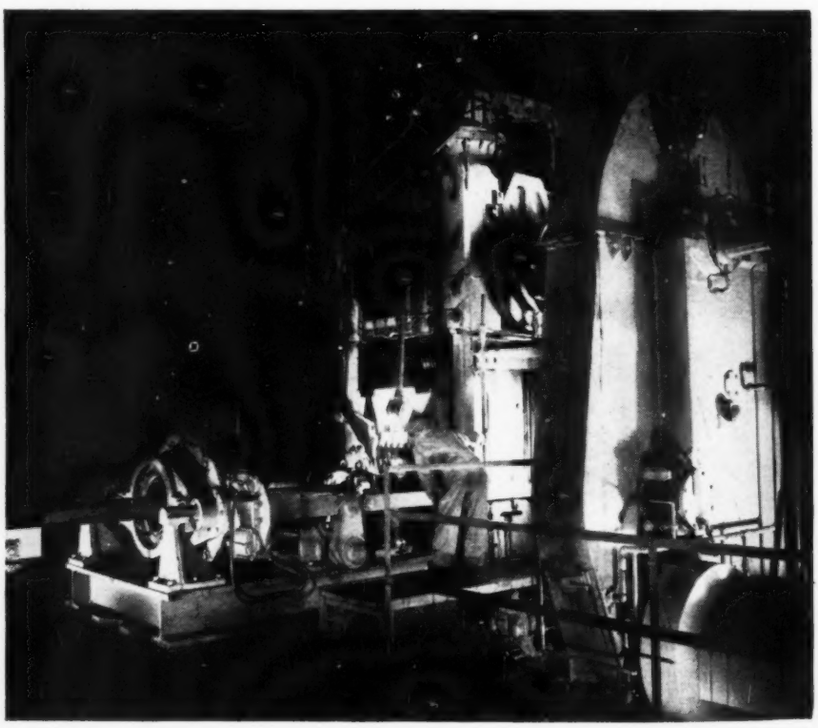
A. O. Smith Now Full-Line Casing Manufacturer

THE A. O. Smith Corporation, Milwaukee, Wisconsin, is now a full-line manufacturer of oil-well casing, having a complete range of A. P. I. standard sizes to 5½ in. OD. and in wall thicknesses to meet virtually any casing need.

Simultaneous with this announcement is another that Smith casing is now available in four grades, including a new high-yield casing called Super Yield casing.

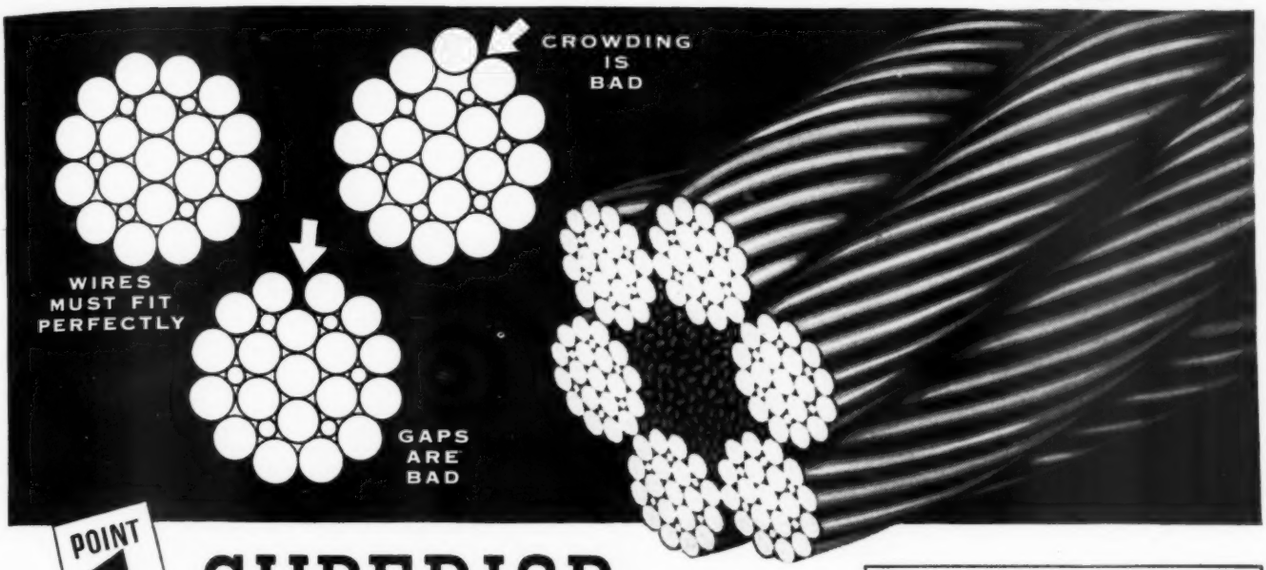
Having a minimum yield point of 105,000 lb. per sq. in., Super Yield casing is made in the smaller sizes for high collapse pressures. Involving radically new methods of manufacture, the new small sizes, like all Smith casing, are made from rolled steel plates. This permits thorough examination of the steel before manufacture and assures uniform wall thickness, the makers assert. It is produced in accordance with A.P.I. standards. The new sizes are manufactured in average lengths of 50 ft., this factor considerably shortening the running time for the strings, as fewer joints are required.

A comprehensive book, describing the results of recent Smith studies and tests on casing, is now in preparation and will be ready for distribution in the near future.



Smith high-yield casing emerging from a special machine developed for its manufacture

QUALITY wire rope



POINT 1

SUPERIOR *DESIGNING*

The designing of wire rope is by no means a simple matter—but on the contrary involves mathematical computations of a most complex and difficult type. There are upward of 80 different constructions of wire rope in use, and each is available in all sizes for which it is recommended. Wire diameters must be computed with absolute accuracy for every size in every construction. If computations are not accurate, and if wires are not of the diameters specified—the wires in the strands will not group together accurately, to give a snug, firm strand. On the contrary, there will be unfilled gaps between wires—or wires will be crowded out of correct position. Either of these conditions will produce an imperfect and short-lived rope.

Expert and mathematically accurate designing by rope engineers of long experience, is one of the important factors in the production of UNION Wire Ropes. Examine any UNION strand. You'll find the wires fit perfectly in place, neither crowding nor leaving gaps.

Specify UNION ordinary or pre-formed ("UNION-formed") and you will be certain of rope that is accurately designed and fabricated.

UNION WIRE ROPE CORPORATION . . . . . KANSAS CITY, MO.

Sales Offices: Beacon Bldg., Tulsa, Okla.; Fort Worth, Texas; Houston, Texas; Chicago, Ill.

Gulf Coast Distributors:
PLOWDEN SUPPLY CO.,
3200 Navigation Blvd.,
Houston, Texas

JARECKI MFG. CO.
DISTRIBUTORS:
Midcontinent, Gulf Coast, New Mexico and Eastern Oil Fields

Export Agents:
LUCEY EXPORT CORP.,
Woolworth Bldg., New York;
Broad St. House, London

UNION

WE RECOMMEND

union
FORMED
(PRE-FORMED)

FOR

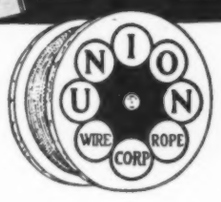
ROTARY DRILLING LINES

TUBING LINES

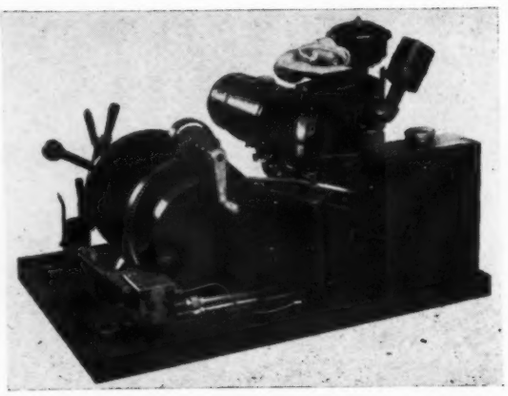
SUCKER ROD LINES

ALL ROPES which must endure severe bending

May we place you on our mailing list for our informative bulletin, "ROPE DOPE?"



Mathey Type E Measuring-Line Reel



TO MEASURE depths, locate obstructions, determine fluid levels, and run bottom-hole pressure and temperature bombs the Mathey Type E measuring-line reel is being introduced. It is designed for deep-well work and has a capacity for 12,000 ft. of .072 line. The Type E unit can be mounted in a portable wooden box (27½ in. by 38 in. by 21 in.) having handles and aluminum covers. It can also be mounted on a steel plate or in a car trailer. It is a self-contained unit, has chain drive, and is powered by a 4-hp. gasoline engine. The reel is a heavy one-piece cast spool. The unit is equipped throughout with ball bearings and has a spring cushioned clutch with a large friction area. The emergency brake is of the lever type, the band working in a groove on one flange of the spool. On the other flange of the spool gear teeth are cut, which provide a drive for the hand crank and hydraulic governor.

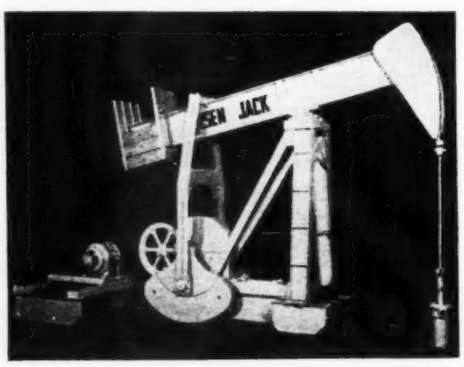
The hydraulic governor is a unit to control the speed of instruments or weights being lowered into the well. By using this device, in connection with Mathey measure-meter, the operator can locate lost tools, determine the distance to fluid, bottom of hole, or any obstruction in the well. If the instrument becomes lodged the pressure gauge immediately indicates this obstruction and the rate of descent may be checked, often avoiding an expensive fishing job.

The hydraulic speed control is similar to the hydraulic governor and the control is the same (by throttle valve).

The equipment is made by C. A. Mathey Machine Works, Tulsa, Oklahoma.

Jensen Model D Pumping Unit

THE accompanying illustration shows one of the new Model D pumping units just placed on the market by Jensen Brothers Manufacturing Company, Coffeyville, Kansas. This improved model has new style cranks and crank weights, and is mounted (optional) on a Jensen sub-base. The unit shown has a wire line or cable head straight lift, but may also be had with a straight-lift mechanism. The company constructs this unit in ten sizes for wells ranging in depth from 500 ft. to 6000 ft. It may be powered by any constant speed prime mover.



Literature on the new Jensen unit says in part: "To increase the flexibility of our pumping unit, we have found that a rotary counterbalance in conjunction with an adjustable static counterbalance affords the best results."

To obtain clearance when servicing a well equipped with a Jensen unit, it is a simple matter to remove the equalizer bearing support and let it swing out of the way, the makers state. This arrangement works equally well with either the special straight-lift mechanism or the conventional cable head, it is asserted.

Bottom-Hole Choke

THE Cameron Bottom-Hole Choke is constructed to allow the well to be washed through it. The positive bean is held against its seat by a light coil spring. When washing-in is begun, the bean is unseated, uncovering an annular space around the bean and inside the body. The fluid may pass downward through this annular space and also through the choke bean. The bean is returned to its seat after the washing operation by the action of the spring and the well pressure. Wear on the positive choke bean has been found to be exceedingly slow, the manufacturer states.

This choke was designed to be made up in the tubing one or two joints from the bottom of the string. Under normal circumstances, in high-pressure wells, at least two chokes are used so that pressure may be reduced in stages. Positive choke beans are made of Nitralloy, and are available in sizes from 16/64 in. to 48/64 in., by 1/64 th.

Detailed engineering and performance data will be supplied on request by Cameron Iron Works, Inc., Houston, Texas.

Kibele Illinois Special Swab

KIBELE Manufacturing Company, Dallas, Texas, announces a new type of 2-in. swab that is given the name of Illinois Special. It is designed for areas where swift descent of the swab through the fluid is desired and the height of the fluid column is not excessive.

The Kibele Illinois Special features a bore through its mandrel that is larger than in the 2-in. Regular type. The Regular 2-in. swab is designed for deep wells where production is heavy.

No part of the Illinois Special swab is interchangeable with the Regular swab. Parts of the 2-in. Illinois Special will be stamped "SP" and parts of the Regular Swab will be stamped "REG."

Stainless-steel Welding Electrode

THE Lincoln Electric Company, Cleveland, Ohio, announces a new arc-welding electrode of the 18-8 type that contains 3½ percent of molybdenum.

The new electrode, designated "Stainweld C," was developed by Lincoln engineers to meet a demand for an arc-welding electrode to weld stainless steels that contain approximately 3½ percent molybdenum. "Stainweld C" provides weld metal of proper physical and chemical properties for welding such steels, it is stated. A coating is provided on the electrode that prevents oxidation of the weld metal and keeps the analysis of the deposited metal virtually the same as the parent metal.

Weight Indicator for Slim-Hole Drilling

MARTIN-DECKER Corporation, Long Beach, California, has announced the development of a new weight indicator especially designed for use in shallow drilling. This new instrument, known as the Slim-Hole Weight Indicator, has a capacity of

150,000 lb. with six lines, ample for the drilling loads encountered in shallow fields and in core-testing work, the manufacturers state. Five interchangeable dials, calibrated in points on both sides (making ten dials in all) give direct reading on all conventional string-ups and line sizes. The instrument accommodates all lines from ⅝ in. to 1¼ in. in diameter. Readings cover more than 360 deg. of the dial circumference, and the large etched numerals insure full visibility from any part of the rig floor.

An important new feature of the Slim-Hole Weight Indicator that contributes to its compactness and lighter weight is the unique design of the gauge case. The case is made entirely of government specification bronze, and the diaphragm unit is an integral part. This makes the instrument extremely compact and easily portable. A newly designed "C" clamp has been incorporated in the equipment that is self adjusting on all size lines, eliminating the use of shims when attaching the instrument to different size lines.

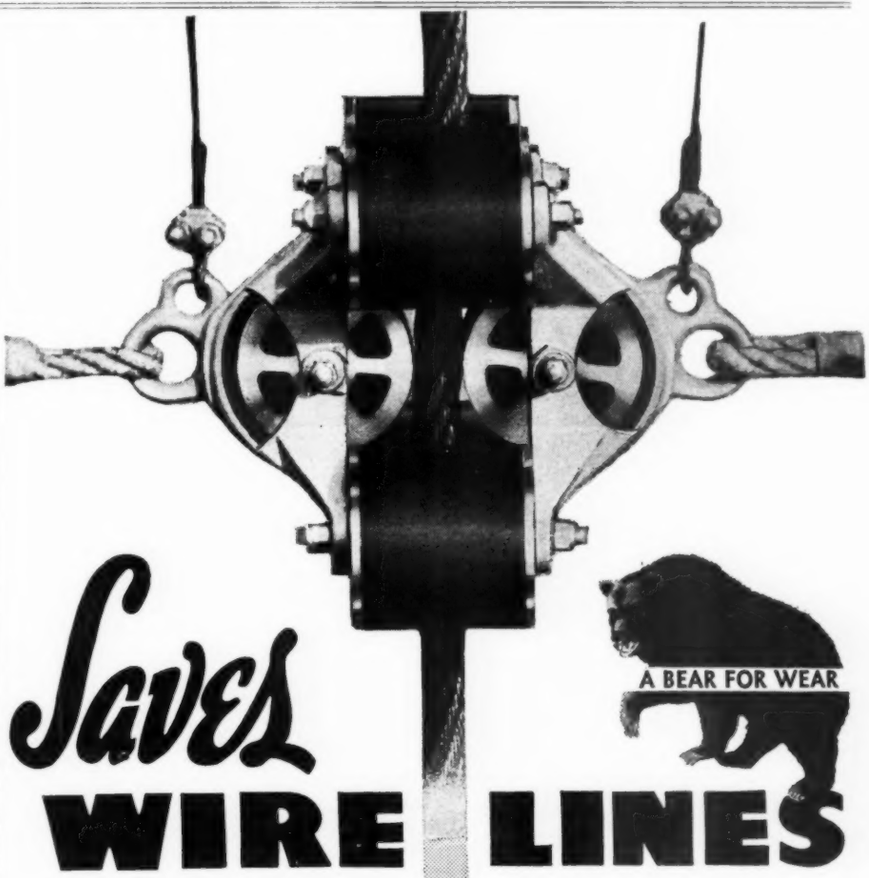
The Slim-Hole Weight Indicator is ruggedly built throughout to give long, trouble-free wear in all shallow-drilling operations, it is stated. It is accurate, extremely sensitive, and is factory tested, calibrated, and sealed, ready for attachment to the deadline. It requires no attention of any kind while in use on the rig.

Differential Valve for High-Pressure Gas Wells

JOS. A. Coy Company, Inc., Tulsa, Oklahoma, is marketing the Coynco high-pressure differential shutoff valve, used in high-pressure gas areas to close automatically a well in the event of a break in the line or a fire at the plant. The Coynco Valve is placed on the gas line leading from the well, and just beyond the choke. The differential in pressure created by a break in the line instantly shuts the well in, thus eliminating fire hazard, loss of gas, and cratering of the well.

When the Coynco Valve is installed on the gas line, the pressure is bypassed into the valve by a connecting line that divides and enters the valve bonnet above and below the highest and lowest position of the piston. Each of these lines is equipped with a small high-pressure valve. Another lead is taken from the gas line on the downstream side. This small line is also fitted with a valve.

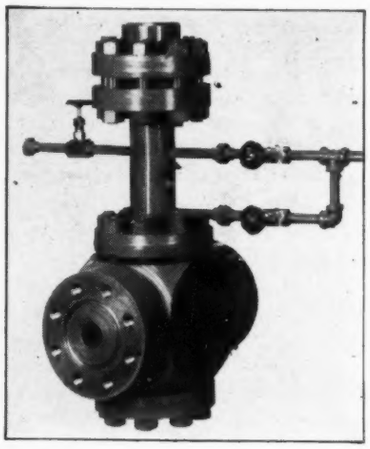
As the Coynco high-pressure differential shutoff valve operates on a differential pressure a line break results in the necessary differential on the downstream side of the valve, automatically closing it. After the line is repaired the valve is reopened by a reversal of the closing operation.



The Grizzly "No-Wip" Line Saver protects life and property while saving thousands of dollars of wire lines every year. Not a rigid line guide, it can be suspended at any point in the rig; hangs free and functions perfectly at any angle or height, regardless of how installed. Eliminates whipping, and the usual bow and whip due to momentum when pulling up an empty block and elevator. Forces line to track perfectly; eliminates piling up; simplifies spooling. Ask your supply dealer or write for Bulletin No. 10-OF.

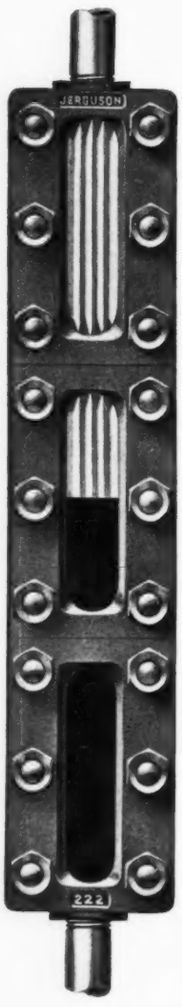
E. M. SMITH COMPANY
600-650 South Clarence Street, • Los Angeles, California, U. S. A.
Complete Stocks Maintained in Our Warehouses At: 1121 Rothwell St., Section 16, Houston, Texas. 1008 S. E. 29th Street, Oklahoma City, Okla. Export Office: Continental Emsco Co., 30 Rockefeller Plaza, New York, N. Y. Distributed By Leading Supply Companies.

GRIZZLY "No-Wip" LINE SAVER



The Coynco Valve is made with a forged-steel body, bonnet, and cap, operated either in an open or closed position by means of a piston in conjunction with a feather valve. The valve mechanism consists primarily of feather and stem, both of stainless steel, and a piston on top of the stem that operates in the bonnet. A spring in the top of the bonnet comes in direct contact with the top of the piston. Tension is controlled by an adjusting screw through the top of the bonnet and made gas tight by means of a cap. All flange connections are series 150 and have ring joints. A strainer on the small line removes all dirt and foreign matter from the gas.

JERGUSON



REFLEX GAGES
Stand for
Safety and Accuracy

They indicate unmistakably the liquid level in tanks, towers, stills, etc.

Ideal for gasoline, kerosene, oil, etc., because—no matter what the color of the liquid—the

EMPTY SPACE SHOWS
WHITE

LIQUID LEVEL APPEARS
BLACK

ACCURATE at all temperatures and pressures.

SAFETY assured for men and equipment.

Easy to install — easy to read.

Jerguson Transparent (thru vision) Gages are used when color and density of liquids must be shown.

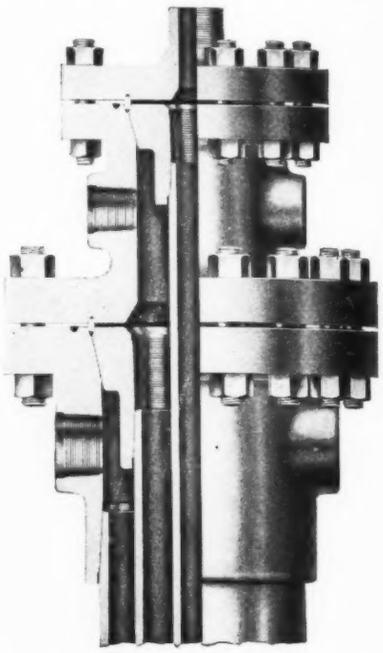
Jerguson Gages are Best
by every real test.

Write for catalog

JERGUSON GAGE & VALVE CO.
89 Fellsway
SOMERVILLE MASSACHUSETTS

Casinghead and Tubinghead by Rector

THE Rector Well Equipment Company, Fort Worth, Texas, announces the addition of a new type of casinghead and tubinghead to its line of equipment. This new head, designated as the Type 6M, is of the mandrel type of suspension, and is flanged above the suspension and packing medium.



The Type 6M casinghead and tubinghead, shown in the accompanying illustration, is compact, rugged, and easily installed, the manufacturer states. The Rector patented sealing ring accomplishes the sealing of pressures and also provides a hold-down on the mandrel. The mandrel is supplied either threaded or welded directly to casing.

The tubinghead is double flanged when applied to the top of the flanged casinghead. This same tubinghead may also be supplied with female threaded bottom connection when it is to be installed on a casinghead having threaded upper connections, such as the Rectorhead in any of its various types, or other casingheads of the upper threaded type.

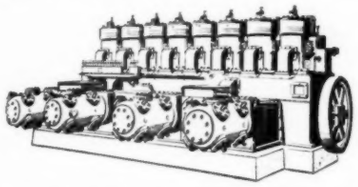
Mandrels of the Type 6M head are designed to pass through blowout preventers that may be installed on the well, prior to the setting of casing or tubing. This keeps the well under full control during the operation.

The head is of cast steel, and is supplied in 4000-lb. test with A.P.I. 600 Series flanges, and in 6000-lb. test with A.P.I. 900 Series flanges. Further information will be sent on request to Rector Well Equipment Company.

Clark Announces Gas-Diesel Engine; New Compressor

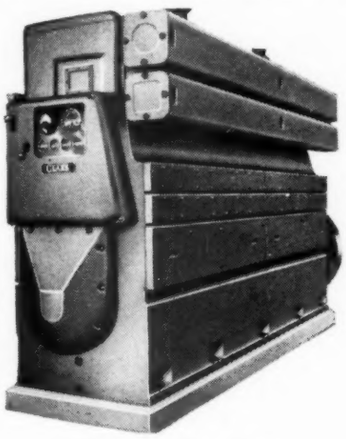
A NEW line of convertible 4-cycle gas-Diesel engines has been announced by Clark Bros. Company, Olean, New York.

These new engines are completely enclosed, have oil-cooled pistons, full force-feed lubrication, and offer an entirely new feature, the Clark "Cetane Selector." By means of the "Cetane Selector" the operator can change the fuel timing without shutting down the engine, thus making possible the use of a wider range of fuels, the manufacturer states.



8-cylinder, 800-hp., right-angle compressor

The engines have 10-in. bore and 12-in. stroke and are available in 3-, 4-, 6-, and 8-cylinder sizes, ranging from 180 to 480 b.hp. for gas and 200 to 535 b.hp. for Diesel.

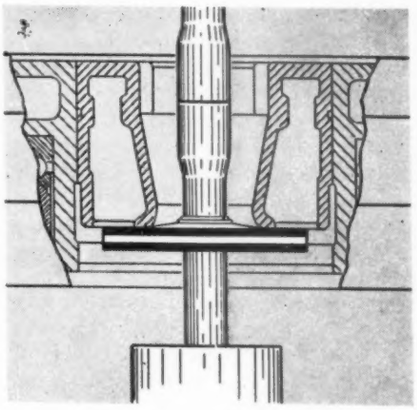


Clark gas-Diesel engine

Clark Bros. Company also announces that its right-angle compressor, built heretofore in 2-, 3-, 4-, 5-, and 6-cylinder sizes, is to be offered also in an 8-cylinder, 800-hp. size. This larger size is offered especially to meet a demand of the larger natural gas companies who have found the angle-type compressor satisfactory for booster station service. The 8-cylinder size, however, will be suitable for many types of service. Two of the 8-cylinder "angles" have been sold to the M. W. Kellogg Company, of New York, to be installed in a Texas refinery. It is stated that by using the new 8-cylinder angle it will be possible to install a 3200-hp. gas booster station in a floor space 24 ft. by 105 ft.

Medearis Dri-Pipe Wiper

AFTER more than a year and a half of experimentation, the Medearis Oilwell Supply Company offers a drill-pipe wiper that, according to the manufacturer, prevents the dilution of rotary mud and the necessity of reconditioning it on each round-trip. It is marketed under the trade name "Medearis Dri-Pipe Wiper."



This drill pipe wiper has two rigid clamping rings of non-sparking metal that hold a circular red rubber wiping disk. This disk is molded of a specially compounded rubber, and has a control

FOR SHALLOW HOLE DRILLERS

IT'S THE NEW

MARTIN-DECKER

SLIM-HOLE WEIGHT INDICATOR

—and, brother, it's got *performance* written all over it.

It's as compact and solid as a welterweight and will handle your toughest shallow-hole jobs right down to the last foot.

Five interchangeable dials, calibrated both sides, handle all standard string-ups and line sizes from 5/8 in. to 1 1/4 in. And a new type clamp is used that requires no adjustments, no shims, for handling any of these lines.

Then check this—it has a built-in pulsation damper that works *automatically* . . . keeps the instrument *always* sensitive, *always* accurate to weight changes . . . and *always* readable even in the roughest drilling.

Another thing—the all-bronze gauge case is virtually one solid piece and the diaphragm unit is built right into it . . . a new type construction worked out by Martin-Decker engineers especially for the *Slim-Hole* Indicator. No water can get in, no fluid can leak out, and no pumping or adjusting is necessary.

You can't beat this instrument for accurate weight control on quick jobs and shallow operations. So if that's where your work is, find out about this new instrument from your nearest Martin-Decker or Reed Roller Bit representative. Or drop us a line and we'll gladly send complete information.

MARTIN HOME OF THE WEIGHT INDICATOR DECKER CORP.

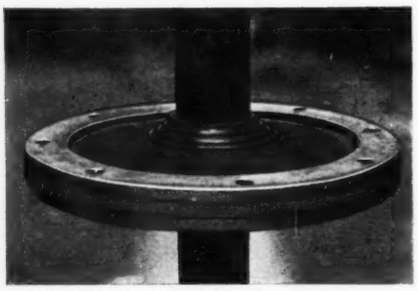
LONG BEACH, CALIFORNIA

SAN JOAQUIN VALLEY: A. F. McQUISTON, BAKERSFIELD, CALIFORNIA

MID-CONTINENT DISTRIBUTOR: REED ROLLER BIT COMPANY, HOUSTON, TEXAS

hole surrounded by concentric beads correctly spaced for the various sizes of pipe. As the central hole becomes enlarged through wear, the rubber can be cut away to the next bead to provide a new wiping surface for the next larger size of pipe.

This wiper, according to the manufacturer, cleans the pipe without the use of wash-water and returns all the mud and weight material to the hole. By preventing dilution of the drilling fluid, the wiper eliminates the necessity for reconditioning the mud on each round-trip, avoids the hazard of



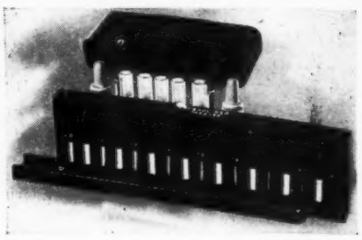
the fluid column being lightened to a degree that might result in a blowout, and facilitates study of the porosity and absorption characteristics of the formation.

The Dri-Pipe Wiper is also used to wipe tubing and sucker rods, special oil-resisting rubber wiping disks being supplied for this service. Further details are available from the Medearis Oilwell Supply Company, 8638 Otis Avenue, South Gate, California.

pH Slide Comparator

A NEW slide comparator for the colorimetric determination of pH, chlorine, and phosphates has been developed by W. A. Taylor and Company, 872 Linden Avenue, Baltimore, Maryland.

The equipment is molded entirely from plastic. Changes in design have resulted in marked improvement in appearance, durability, and ease of handling, the manufacturers state. The weight has also been considerably reduced. All pH, chlorine, and phosphate values, as well as the indicator names, are engraved in white directly on the plastic slides. Improved catches are used to hold the top on the base and all metal parts are rustproof. The complete unit, including the slide, is 10 in. long, 2⅛ in. wide, and 4 in. high and weighs 1½ pounds.



The new comparator consists of a slide and a base. Each slide contains nine color standards alternating with ampoules of distilled water. All color standards are guaranteed by the manufacturer to maintain their accuracy for a period of five years.

The base contains two vials of indicator solution, with 0.5-cc. pipettes, five 5-cc. test tubes, and a piece of etched glass in a special compartment. Determinations are made by filling three of the test tubes with the test sample, adding 0.5 cc. of indicator solution to the middle one, placing the slide on the base and moving it back and forth until the test sample matches one of the color standards. The pH, chlorine, or phosphate value is then read directly from the values on the slide. One base can be used with any number of color standard slides. Full information can be obtained from the manufacturer.

Make Your Drilling Job **EASIER** *and* **SAFER**

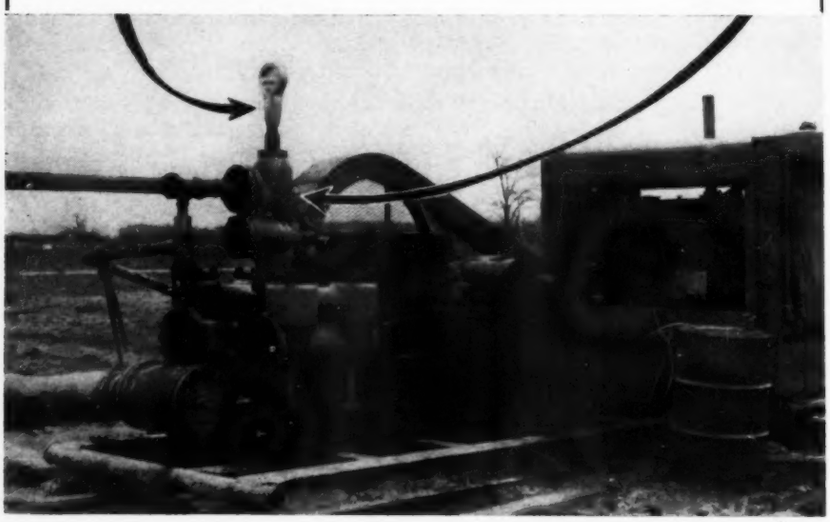
LIKE THIS ILLINOIS OPERATOR IS DOING —

This Sandoval, Illinois, job has the last word in slush pump protection. The 6" x 12" power pump is equipped with a SHEAR-RELIEF Valve, which protects the fluid end, the manifolds and drilling hose against excess pressures by the shearing of the nail should pressure reach the set point. It is also equipped with an Abercrombie Pressure Gauge, which gives a uniform reading of pump pressure under all operating conditions, as far as 30' distances.

LEFT: This gauge functions equally well on mud, water, oil, air, gas, or any liquid line . . . and is credited with taking gauges out of the delicate instrument class. Pressure ranges: 0-1000, 0-3000, 0-5000 lbs. per sq. in.

RIGHT: This low pressure SHEAR-RELIEF Valve is for all hydraulic service up to 1000 lbs. The high pressure type, for larger pumps and flow line service, has a pressure range up to 2750 lbs. per sq. in.

FLUID-PISTON SLUSH PUMPS
ABERCROMBIE PUMP CO.
GULF BLDG. HOUSTON TEX.



H. F. Stover Made Secretary-Treasurer of Gaso

Howard F. Stover, purchasing agent and assistant to the late L. D. Armstrong in the Gaso Pump and Burner Manufacturing Company organization

HOWARD F. STOVER

has been appointed to succeed the latter as secretary-treasurer and manager of the company. Tom H. Flanagan, son of T. J. Flanagan, president of the company, assumes Stover's former position.

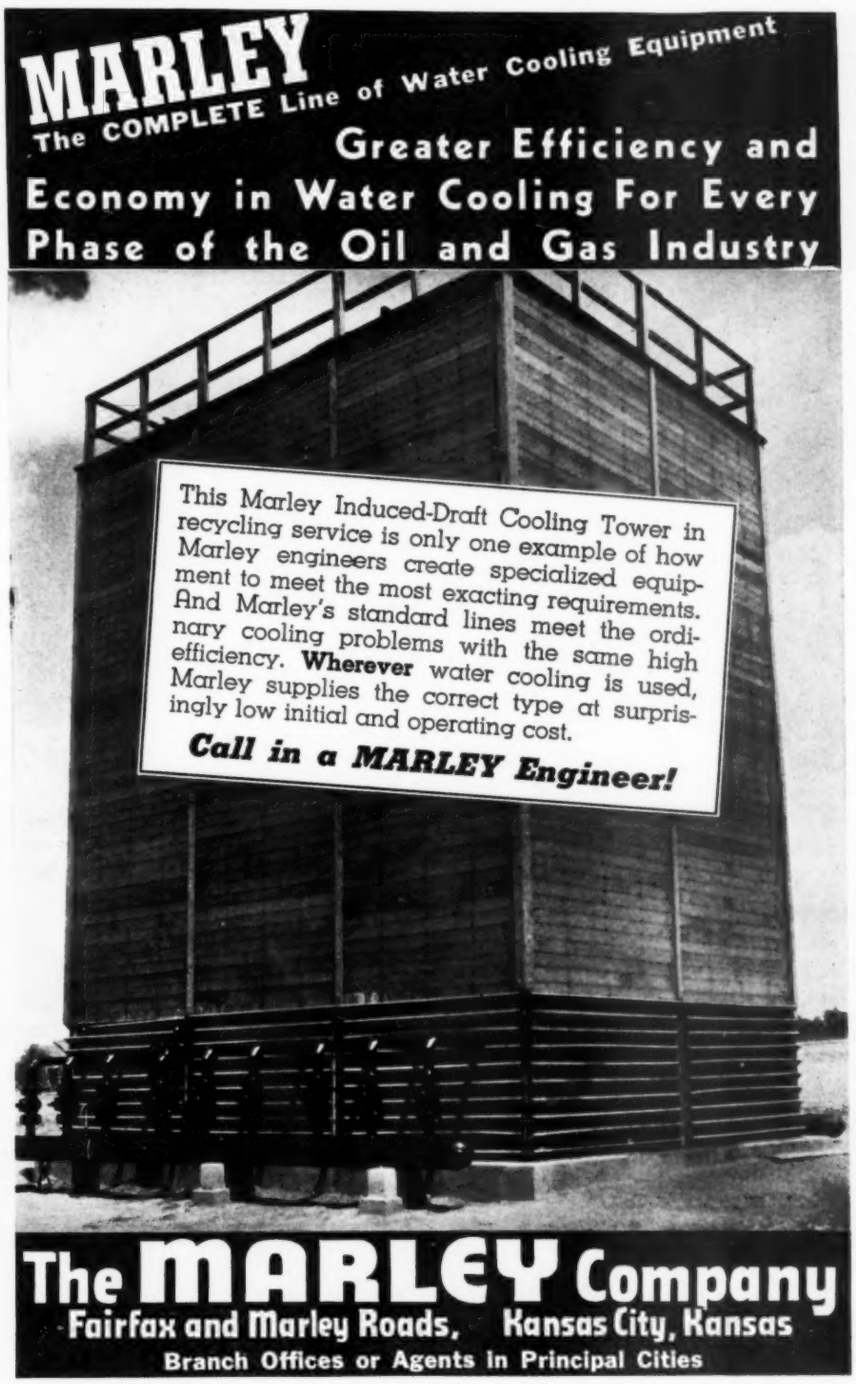
Stover is a native of West Virginia, but his family moved to Tulsa in 1906 when he was seven years old, and he received most of his education in Tulsa schools. His first job was with the Gulf Oil Corporation, in its warehouse department, and was followed by service in the World War. After the war he became associated with the Sinclair Pipe Line Company in its materials department, leaving the company in June, 1920, to accept a position with the Gaso company.

TOM H. FLANAGAN

In succeeding Armstrong as secretary-treasurer and manager of the Gaso company, he will have complete supervision of manufacturing and of the company's domestic and export sales.

Tom H. Flanagan, who becomes purchasing agent and assistant to Stover, received his education at Kemper Military Academy and Tulsa University, and entered the employ of the Gaso company in 1934, spending more than a year as a mechanic in the company's shops. He was then moved to the office as assistant to Stover.

Personnel of the Gaso organization is otherwise unchanged. T. J. Flanagan continues as president, M. J. Flanagan as vice-president and general manager, I. C. Hughlett as plant manager, R. L. Jaeger as chief engineer, Russell Peoples as shipping clerk, H. A. Wienecke, Jr., as sales representative for Oklahoma, Kansas, Illinois, Indiana, and Michigan, G. W. Dreyer as sales representative for Texas, Louisiana, Arkansas, and New Mexico, and A. V. Simonson as New York export manager.


MARLEY
The COMPLETE Line of Water Cooling Equipment
Greater Efficiency and Economy in Water Cooling For Every Phase of the Oil and Gas Industry
This Marley Induced-Draft Cooling Tower in recycling service is only one example of how Marley engineers create specialized equipment to meet the most exacting requirements. And Marley's standard lines meet the ordinary cooling problems with the same high efficiency. Wherever water cooling is used, Marley supplies the correct type at surprisingly low initial and operating cost.
Call in a MARLEY Engineer!
The MARLEY Company
Fairfax and Marley Roads, Kansas City, Kansas
Branch Offices or Agents in Principal Cities

Baker Acquires St. Louis Plant

Baker Oil Tools, Inc., announces the acquisition of the plant and equipment of the Bartlesville Supply Company at St. Louis, Missouri, where manufacture of Barsco products will be continued, both for domestic and for export distribution.

G. D. Hall has been appointed plant manager, C. A. Walker will continue as plant superintendent, and J. O. Buchta will be special sales representative for Barsco products.

According to the announcement, Baker Oil Tools, Inc., plan to improve manufacturing facilities at the recently acquired plant in line with the increased importance of St. Louis as a manufacturing and distributing point for oil-well tools.

D. W. Henke Manager Merla Tool Company

D. W. Henke, who until recently was secretary-treasurer of the Guiberson Corporation, and for 23 years a business associate of S. A. Guiberson, Jr., founder of the business that bears

D. W. HENKE

his name, has been announced as manager of the Merla Tool Company, Dallas, Texas.

Henke's long career with the Guiberson Corporation has made him a familiar figure throughout the oil fraternity. His association with Guiberson dates back to 1915 when the latter was operating as an individual in Los Angeles, California. In 1919 Guiberson moved to Dallas and established the Guiberson Corporation. Henke was made assistant treasurer at that time and later became secretary-treasurer. He also served as secretary-treasurer of the Guiberson Diesel Engine Company; vice-president and treasurer of the Algord Oil Company, and secretary-treasurer of the Two-Well Corporation. On April 1st he tendered his resignation to become secretary, and a member of the board of directors and executive committee of the Guardian Life Insurance Corporation, Dallas. His new connection with the Merla Tool Company will not alter his position with the Guardian Life Insurance Corporation.

Serving on the executive staff of the Merla Tool Company with Henke are: Roy A. Lamb, in charge of sales, and C. S. Crickmer, in charge of engineering and production.

The Merla Tool Company, established a few years ago, manufactures a complete line of gas-lift equipment for oil wells.

Foreign Club Organized

Realizing that a community interest exists between men who have traveled in foreign fields in the interest of oil equipment manufacturers, a group of such men got together in California several months ago and organized an association. At a series of bi-weekly luncheons details of organization were perfected, by-laws formulated, and the name "Nomads" selected. Believing that the association should be national in scope and that oil-equipment representatives in other sections of the country might wish to join in the movement, the group decided to make its organization a Los Angeles Chapter and invite others to form similar chapters in their localities. Such chapters are being formed in Houston and Tulsa.

The name "Nomads" is taken from the initial letters of the full name of the association which is National Oil Equipment Manufacturers and Delegates Society. Its objects are strictly fraternal and educational and its regular meetings will consist of monthly dinners at which the members can renew acquaintance and be entertained by programs arranged by the entertainment committee.

Active membership in the Nomads is limited to men who have actually visited foreign countries in the interest of oil-equipment manufacturers. Associate members are men who devote a substantial portion of their time to oil-equipment export business. From time to time honorary members will be selected from men who have attained outstanding positions while in foreign service for oil companies.

Officers elected by the Los Angeles Chapter are: E. L. Decker, Martin-Decker Corporation, president; F. C. Ripley, Emsco Derrick and Equipment Company, vice-president; W. F. Bettis, M. O. Johnston Oil Field Service Corporation, secretary-treasurer; Earl Rees, Fluid Packed Pump Company, assistant secretary-treasurer; Henry Pullman, Baker Oil Tools, Inc., sergeant-at-arms; and E. B. Fowks, Emsco Derrick and Equipment Company, assistant sergeant-at-arms.

The present membership of the Los Angeles Chapter consists of: George Anderson, Baker Oil Tools, Inc.; J. C. Axelson, Axelson Manufacturing Company; Carlton Baker, Jr., Baker Oil Tools, Inc.; Jack Ballagh, Patterson-Ballagh Company; W. F. Bettis, M. O. Johnston Oil Field Service; S. R. Bowen, S. R. Bowen and Company; B. Bronzan, Baash-Ross Tool Company; Frank Champion, Byron-Jackson Company; Larry Coker, National Supply Company; B. W. Davidson (deceased), M. O. Johnston Oil Field Service; E. L. Decker, Martin-Decker Corporation; Norman Dorn, Lane-Wells Company; Calvin Drake, Hydril Company; Joe Dunn, National Supply Company; John Eastman, Eastman Oil Well Survey Company; R. J. Eiche, Lorraine Corporation; J. E. "Brick" Elliott, Elliott Core Drilling Company; E. B. Fowks, Emsco Derrick and Equipment Company; John Grant, Grant Oil Tool Company; Abe Haglund, Axelson Manufacturing Company; L. T. Hamer, Hamer Oil Tool Company; Clarence Hill, Oil Well Supply Company; Ray Humphries, Axelson Manufacturing Company; Clay Johnson, Shaffer Tool Works; Blaine Johnston, Jr., M. O. Johnston Oil Field Service; A. D. Love, Chiksan Oil Tool Company; Tom Martin, Lorraine Corporation; W. R. "Frosty" Martin, Martin-Decker Corporation; Roy McCollum, Parkersburg Rig and Reel Company; C. J. McLaren, Hughes Tool Company; Floyd Merritt, Elliott Core Drilling Company; Harry Morehouse, Wagner-Morehouse; Tom Murphy, Martin-Decker Corporation; L. J. Paddock, Stoody Company; Henry Pullman, Baker Oil Tools Inc.; Geo. Ratcliffe, Baroid Sales Company; L. A. Rawson, Stoddard-Rawson, Inc.; Earl Rees, Fluid Packed Pump Company; F. C. Ripley, Emsco Derrick and Equipment Company; S. R. Robinson, Yowell Service Company; Hans Ross, Baash-Ross Tool Company; Wallace Sawdon, *The Petroleum Engineer*; Walter Seymour, Non-Corrosive Products Company; E. R. Smith, Lane-Wells Company; Roland Smith, Byron-Jackson Company; Ted Sutter, Baker Oil Tools, Inc.; Joe Swaton, Kerotest Manufacturing Company; Harry Therolf, Eason and Therolf Tool Company; Ed Thompson, Security Engineering Company, Inc.; Clarence White, Oil Well Manufacturing Corporation, and Jack Wilcox, S. R. Bowen and Company.

W. H. Kreer Advanced

W. H. Kreer, formerly middle-west sales engineer for Templeton, Kenly and Company, Chicago, Illinois, has been placed in charge of the company's Dallas, Texas, office to replace Charles Neher, who passed away recently. Kreer has an intimate knowledge of the Simplex Jack line, having been with the company for many years prior to his recent re-employment, and is well acquainted with the petroleum industry through his contact with Illinois Basin, Michigan, and Ohio producers.

W. H. KREER

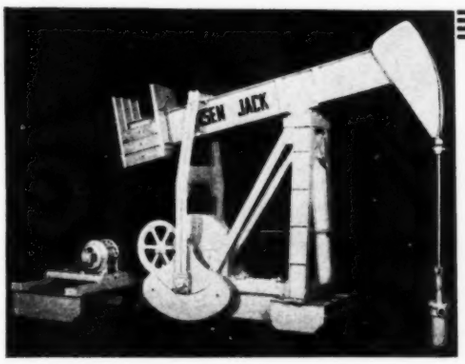
Special Representative

E. T. Eggers has been appointed special representative on wire rope for the Gulf Coast oil fields by the American Steel and Wire Company, subsidiary of United States Steel Corporation. His headquarters will be in the Praetorian Building in Dallas, Texas. Eggers joined the staff of the American Steel and Wire Company in 1934 as a salesman in the Philadelphia office and subsequently was transferred to Dallas and then to Houston.

E. T. EGGERS

Colloid Symposium Notes Available

Stenciled copies of the proceedings of the Colloid Symposium conducted at the University of Oklahoma, Norman, by Dr. Ernst A. Hauser, professor of colloid chemistry at Massachusetts Institute of Technology, are now available, it has been announced. The notes contain a summary of the four-days' lectures and discussions on colloid chemistry as related to the petroleum industry. The book, which contains 100 pages, can be obtained for 75 cents per copy upon request to the University of Oklahoma.



This New JENSEN UNIT

It's the same JENSEN Unit that has always commanded respect progressively because of its great stamina. But it now has new style cranks and crank weights, a special JENSEN sub-base, and other improvements guaranteed to further its well-known capacity for cutting production costs to the very bone. You'll want to know more about it, of course. Even a producer satisfied with his present equipment wants to keep abreast. So get in touch with your JENSEN dealer or wire us at Coffeyville.

JENSEN BROTHERS MANUFACTURING CO.

. . . . . *Coffeyville, Kansas*

EXPORT OFFICE: 136 LIBERTY STREET, NEW YORK

SEND FOR THIS NEW 272 PAGE DATA BOOK

• Between the covers of this new book are presented in convenient, compact form, complete engineering and reference data on—self-aligning anti-friction ball and roller bearing units . . . unmounted radial-thrust bearings . . . babbitted bearing units . . . base plates . . . take-ups . . . clutches, including the famous Twin Disc line . . . gears . . . pulleys . . . collars . . . couplings . . . hangers . . . shafting—the latest designs of the leading manufacturer of power transmission equipment. 272 pages of illustrations, dimensions, weights, list prices, engineering information, cross-indexed for convenient use of design engineers and plant managers. Return the coupon for your copy.

LINK-BELT COMPANY
300 W. Pershing Road, Chicago, or
2045 W. Hunting Park Ave., Philadelphia
Please send copy of new Power Transmission Book No. 1600.

*Name*_____ *Firm*_____
*Business*_____
*Address*_____ *City*_____ *State*_____ 7770-E
Petroleum Engineer

W. H. Cobb Promoted

Willard H. Cobb, for the last several years general factory manager, mechanical goods plants, United States Rubber Company, has been appointed

W. H. COBB

general manager of the Mechanical Goods and General Products divisions.

Herbert E. Smith, vice-president, will continue to be supervisor of all the activities of the divisions.

Security's New Houston Office and Plant

Herewith is shown a part of the new division office, warehouse, and manufacturing plant of Security Engineering Company, Inc., recently completed

at 5525 Clinton Drive, Houston, Texas.

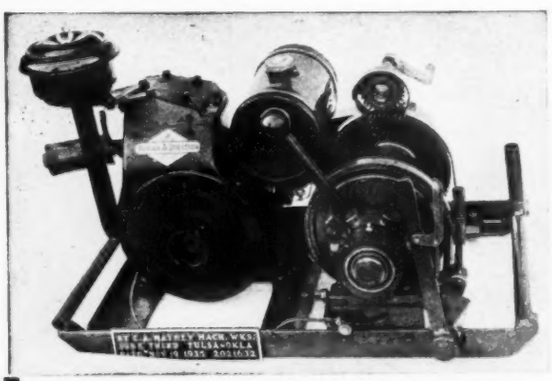
The structure was built by the Austin Company, well-known designers and builders, and includes many innovations in office and plant design and construction.

O. C. S. Establishes Export Department

W. P. "Bill" Turner, president of Oil Country Specialties Manufacturing Company, has announced the establishment of an export sales department at the Pacific Coast plant, 2340 Artesia Street, Long Beach, California. The new department will be equipped to serve all export fields, with special facilities for marketing in South American countries.

The new department will be headed by W. A. Loomis, a member of the O. C. S. organization for the last nine years. Loomis is widely known as the inventor of the O. C. S. Automatic Driller, a power unit for automatically controlling drilling weight.

Lew Cline, former representative for the Titusville Iron Works, and now with O. C. S., recently left New York on a two months' trip to South America for the company. He will visit Venezuela, Colombia, and Trinidad, making an extensive study of the equipment market in the interest of the new export sales department.



Mathey Type G Unit for 5,000' Wells!

A Low Cost Measuring Line Reel

A low cost, sturdy, compact measuring unit, with self-contained gasoline engine, that weighs only 275 pounds with 5,000 feet of line on the drum; two men can easily carry it. Unit will fit in back of small coupe. No changes or special mountings required. Length, 32 inches; width, 19 inches; height, 17 inches.

Capacity, 6,000 feet of .066 line. Ball-bearing equipped throughout. Special type clutch prevents sudden jolt on line and drum when power is applied. Besides regular combination clutch and brake the unit has an extra emergency brake.

Mathey measure meter and accessories available.

Mathey Measuring Units are available for any depth work, with reel capacities from 5,000 feet to 15,000 feet of .072 line.

Write for Details

C. A. MATHEY MACHINE WORKS

Phone 3-3623 212 South Frankfort Tulsa, Oklahoma

Pick a Winner

When you put your wells to pumping, don't bet on a long shot. Select a pump with the reputation of a favorite—let the odds be on your side.

Just as Johnstown was the favorite in the recent Kentucky Derby, O'Bannon Pumps are a favorite throughout the great pumping fields of the Mid-Continent.

O'Bannon Pumps

Arrow Rod Pump
Thrift Rod Pump
DeLuxe Rod Pump
Baby Red Rod Pump
Nu-Standard Rod Pump
Arrow Tubing Pump
Cup & Discpak Plungers
Cro-Lay Working Barrels
Oversize Standing Valves

From the new O'Bannon Catalog Number 9, select the pump best suited to the particular conditions of your wells, and let the experience of a pioneer pump manufacturer help you produce them economically.

WALTER O'BANNON COMPANY

TULSA FORT WORTH

International Petroleum Exposition Re-elects Officers

Suggested plans for a foreign building to be constructed on the grounds of the International Petroleum Exposition in Tulsa, Oklahoma, for the 1940 show were discussed at a recent meeting of the board of directors, at which time officers for the show also were elected.

All officers were re-elected, W. G. Skelly again being named president. Serving with him will be Alf G. Heggem and Frank J. Hinderliter, vice-presidents; Clyde H. Pape, treasurer; Wm. B. Way, general manager; H. R. Powers, secretary; Frank O. Prior, and W. M. Bovaird, executive committee.

The International building, which would also serve as headquarters for foreign delegates to the show, was suggested by General Manager Way as a "building in which all exhibiting oil-producing countries would be invited to display relief maps of their oil development."

"More than 60 percent of last year's exhibitors already have notified the exposition management that they desire the same amount or additional space for the 1940 show," President Skelly told the directors.

Co-chairman Dr. C. K. Francis, who is working with Chairman Dr. Gustav Egloff on the scientific and technical committee, told the directors that his committee already had held one meeting.

Among the phases of scientific development to be stressed at the next show are: corrosion, measuring depths, use of petroleum substitutes, drilling muds, orientation of drill holes, acids, cracking processes, hydrogenation, temperature control, core analysis, and soil analysis.

Working models and moving displays will be used wherever possible.

The 17 leaders in the oil industry who were nominated and invited to serve on the board of directors are: W. L. James, purchasing agent, Stanolind Oil and Gas Company, Tulsa; C. A. Prichard, purchasing agent, Mid-Continent Petroleum Corporation, Tulsa; V. C. Fuller, purchasing agent, Gulf Oil Company, Tulsa; J. R. Freeman, head of traffic and purchasing departments, Carter Oil Company, Tulsa; M. F. Bridges, purchasing agent, Tide Water-Associated Oil Company, Tulsa; O. E. McClatchey, purchasing agent, Barnsdall Refining Company, Tulsa; L. F. McCollum, vice-president, Carter Oil Company, Tulsa; G. A. Tompson, vice-president, Bethlehem-International Supply Company, Tulsa, and H. W. Camp, manager, Cities Service Oil Company, Tulsa.

J. L. Shakely, president, Frick-Reid Supply Corporation, Tulsa; H. M. Cosgrove, secretary, Purchasing Agents' Association of Tulsa; E. A. Cook, purchasing agent, Amerada Petroleum Corporation, Tulsa; Fred E. Cooper, president, Fred E. Cooper Company, Tulsa; G. H. Westby, president, Seismograph Service Corporation, Tulsa; A. A. Buschow, president, Bridgeport Machine Company, Wichita, Kansas; George P. Fenn, assistant in charge of oil field sales, Engine Division, Caterpillar Tractor Company, Peoria, Illinois, and R. Otis McClintock, president, First National Bank, Tulsa.

McKissick Appoints Export Agent

McKissick Products Company, Tulsa, Oklahoma, announces the appointment of A. V. Simonson, having offices at 149 Broadway, New York City, as exclusive export representative. Simonson, through personal contact, is well acquainted with most of the foreign operators as well as the representatives of these operators in New York.

Do YOU want to cut pipe with less effort and less cutter wheel expense?

Then see the faster RIDGID with this Forged Blade Wheel

Profit from RIDGID economy in 1939!

NEW fast cutting that ends your burr problem—because this blade wheel is *thin*. Many more cuts per wheel—because it's forged from special tool steel. That's why the RIDGID Cutter saves you time, work and money. The steel reinforced cutter is warp-proof, always cuts true. You like the well-balanced feel of it, the easy spinning to size. Thousands of enthusiastic users will tell you it has no equal for speedy smooth low-cost pipe cutting. Four sizes for pipe up to (4) inches. Cost no more than old style cutters. Buy from your Supply House today.

THE RIDGE TOOL COMPANY, ELYRIA, OHIO

FAMOUS RIDGID PIPE WRENCHES
CUTTERS • THREADERS • VISES • EXTRACTORS

KINK OF THE MONTH "in the interests of more efficient cleaning"

NEW WAY TO CLEAN FILTER PRESS SCREENS

One refining concern formerly removed hard, black deposits from the fine mesh screen plates of filter presses by long, tedious hand-scraping, supplemented by use of costly solvents. Now, it makes up a hot solution of the recommended Oakite material and circulates this through the filter, first in one direction and then in another ...with the result that screen plates are CLEAN. All residue and scale are gone! Cleaned filter is "good as new."

Write today for further information on easy low-cost Oakite methods on this and other jobs in your plant.

Manufactured only by:
OAKITE PRODUCTS, Inc.
48 Thames Street New York, N. Y.
Representatives in all principal cities of the United States

OAKITE 1909 1939 30 YEARS OF SERVICE

OAKITE certified CLEANING
MATERIALS & METHODS FOR EVERY CLEANING REQUIREMENT

Keeps Discharge Costant—Full-Speed Operation Safe

COMPRESSOR REGULATOR

As a close regulator of pressure on constant-speed pumps, the C-F Compressor Regulator has no equal. Thoroughly dependable in all applications where such a device is needed. Excess discharge pressure flows through and is relieved with no appreciable variation in the suction line. Lever-type regulator is here shown. Spring-loaded type is also available and is equally sure-working. Ask for Bulletin No. 130, also for catalog of all Chaplin-Fulton Regulators.

The CHAPLIN-FULTON MFG. CO.
28-40 PENN AVE. CF PITTSBURGH, PA.

ANOTHER WORLD'S DRILLING RECORD

Kernco 1-36 at Shafter, California
Ran 10,000-ft. string of 5 9/16" drill pipe

This is the longest string of 5 9/16" drill pipe ever run. It was equipped with Patterson-Ballagh Protectors. This same pipe with the same Protectors was previously used in four other wells to 9,000 feet each. The Protectors are still in good condition. Another record for Patterson-Ballagh Protectors.

PATTERSON-BALLAGH CORPORATION
Plant and General Offices: 1900 E. 65th Street, Los Angeles, Calif.
Mid-Continent Office: 1506 Maury Street, Houston, Texas
New York Office: 39 Cortlandt Street, New York City

PATTERSON-BALLAGH
DRILL PIPE AND CASING PROTECTORS

Electrical Bodies to Hold Next Meeting in Dallas

The Petroleum Industry Electrical Association and the Petroleum Electric Supply Association closed a successful meeting in Houston, Texas, by selecting Dallas as the convention city for 1940.

D. W. Sims, of the Continental Pipe Line Company, Ponca City, Oklahoma, was elected president of the Petroleum Industry Electrical Association, to succeed E. M. Smith, of the United Gas Pipe Line Company, Houston. Other officers elected were: O. V. Summers, The Texas Pipe Line Company, Houston, vice-president, and J. F. Collerain, Houston Pipe Line Company, Houston, secretary. Summers succeeds Sims and Collerain succeeds H. E. Browne, of the Sinclair Refining Company, Pipe Line Department, Independence, Kansas.

New officers of the Petroleum Industry Electrical Association: Seated—D. W. Sims, president. Standing, left to right—E. M. Smith, past president; O. V. Summers, vice-president, and J. F. Collerain, secretary.

New officers Petroleum Electric Supply Association: Left to right—T. B. Jones, secretary; G. G. Griffin, president, and J. H. Jamison, vice-president.

New officers elected by the Petroleum Electric Supply Association were as follows: G. G. Griffin, Crouse-Hinds Company, Dallas, president, to succeed George Freeman of Houston; J. H. Jamison, Square D Company, Houston, vice-president, to succeed Griffin, and T. B. Jones, Ohio Brass Company, Dallas, secretary, to succeed Tom Conrad of Tulsa.

Opens Chicago Office

The John Zink Company, Tulsa, Oklahoma, announces the establishment of a Chicago office at 7309 East End Street. The new office is in charge of A. J. Foley, recently sales manager for Hanlon-Waters Company.

Trade Literature

LARKIN PACKER COMPANY, 6200 Maple Avenue, St. Louis, Missouri, in its Bulletin No. 26 illustrates and describes Larkin Rotary Hole Equipment. Several new items are featured. A copy of the bulletin will be sent free to interested persons.

* * *

LINCOLN ELECTRIC COMPANY, Cleveland, Ohio, has published Bulletin No. 359, which discusses the protection of the eyes when welding by use of the Lincoln "Super-Visibility" and "High-Visibility" lenses. Copies of the bulletin will be sent free upon request to the manufacturer.

* * *

BULLETIN No. 1050 describes the Emco Type 38 Orifice Meter, manufactured by the Pittsburgh Equitable Meter Company, 400 North Lexington Avenue, Pittsburgh, Pennsylvania. Phantom drawings present a complete picture of the interior of the meter. Copies of the bulletin are available to those writing the manufacturer.

* * *

WORTHINGTON PUMP AND MACHINERY CORPORATION, Harrison, New Jersey, has issued a number of pamphlets. Bulletin No. L-611-B8 describes motor- and steam-driven feather valve compressors, types HB and HS; Bulletin No. W-321-M3A, Jetflo deepwell pumps; Bulletin No. H-850-B52, gasoline-engine-driven portable compressors; Bulletin No. H-850-B56, Aero, 2-stage, full-Diesel drive portable compressors, and Bulletin No. S-500-B5E, vertical 4-cycle, direct-injection Diesel engines.

* * *

PACIFIC PUMP WORKS, 5716 Bicket Street, Huntington Park, California, have issued a 24-page bulletin on centrifugal hot oil pumps. Full information on Pacific's multi-stage, double-case, forged-steel pumps, explaining new design features, is given. One of the outstanding features is the use of mechanical and floating seals for high suction pressure, high temperature conditions. Copies of the bulletin may be obtained by writing to Pacific Pump Works.

* * *

ALLIS-CHALMERS MANUFACTURING COMPANY, Milwaukee, Wisconsin, has issued a new four-page leaflet 2199-C covering single-suction, single-stage, close-coupled utility pumps that handle from 10 to 1600 gal. per min. and use motors to 75 hp.

* * *

Book Reviews

Oil and Petroleum Year Book (1939). Compiled and published by Walter E. Skinner, 15, Dowgate Hill, Cannon Street, London, E. C. 4, England. 565 pp.

The book gives complete particulars concerning 850 companies engaged in producing, transporting, and marketing oil, financing oil development, or directly associated in any way with the oil industry. This information includes the name of directors and other officials, date established, location of property, or description of business, oil production, capacity of refineries, capital, dividends, and financial condition.

A list of 788 trade names of petroleum products marketed by the various companies is given; a glossary of 141 technical terms and words peculiar to the oil industry is another useful feature, as is the buyers guide.

B-M-W Balls and Seats

Chromard—Genuine Stainless Steel. Most widely used Ball and Seat in the oil fields of the world.

Monarch—Hardest of all non-corrosive Balls and Seats. Outstanding results under most severe conditions.

Bramo—General purpose Ball and Seat. High grade alloy steel. Moderate cost. Very efficient.

Lumonel—Monel Alloy. Extremely non-corrosive. Somewhat harder than bronze.

Bi-Metal—Combination of CHROMARD seat with EXTRARD BRONZE Ball.

Extrard Bronze—Extremely hard bronze alloy. Withstands lodestone conditions. Resists strong corrosive agencies.

The above standard types will efficiently and economically care for most pumping conditions, but for services that are TRULY SEVERE and where LONG LIFE is of importance we recommend our recently developed:

B-M-W TOWER TYPE Ball and Seat
and the
B-M-W 2-WAY NON-MAGNETIC CROWN

Complete data on request. See our advertisement in the "Composite Catalog."

IN ADDITION TO BALLS AND SEATS

other B-M-W products are sold by leading supply stores: ● ADMORE Insert Pump Anchors: ● NEILSON Tools (Safety Sucker Rod Hooks, Tubing Hooks, Rod Elevators, Sucker Rod Sockets, etc.); ● ADMORE LINER BARRELS; ● TEX TYPE Plunger Fittings and Valves; ● COLLINS Belt Clamps; ● FLUID LIFTER Pumps; and ● NU-TEX Pumps.

BRADFORD MOTOR WORKS INC.
OIL WELL SUPPLIES
BRADFORD, PA. — TULSA, OKLA.

SUBSCRIPTION ORDER FORM

THE PETROLEUM ENGINEER,
Box 1589, Dallas, Texas.

(Enter) (Renew) my subscription for one year. My check in the amount of $2.00 is enclosed.

*Name*_____

*Company*_____

*Position*_____

*Home Address*_____

(or)

*Office Address*_____

*City*_____ *State*_____

The Eyes of Texas
Travelers
-look to the
TexasState
★ for extraordinary service
★ for unexcelled comforts
★ for matchless cuisine
No doubt these are the THREE qualifications you look for, too . . . but can't always expect from ordinary hotels.
Next time you come to Houston, try the Texas State. And find out for yourself what other experienced travelers know . . . a service EXTRAORDINARY . . . comforts UNEXCELLED . . . and cuisine UNMATCHED.
Low Attractive Rates
B. F. ORR, General Manager
In HOUSTON
TEXAS STATE
HOTEL

COMPLETELY AIR-CONDITIONED IN SUMMER

YOU will enjoy the friendly atmosphere of Tulsa's most homelike and genial hotel. Whether you stop for a day, a month, or a year every effort will be made to render gracious, prompt, and unobtrusive service in such a way as to make you want to "Come Again."

• **Rates** from $2.50 •

Hotel TULSA

HOLLIS H. HODGES MANAGER

TULSA, OKLAHOMA

T. J. McMahon Passes Away

Thomas J. McMahon, vice-president and director of The Texas Pipe Line Company, Houston, Texas, died of a heart attack at his office desk on May 24. He was born in Karns City, Pennsylvania, December 18, 1882, and as a young man in Pennsylvania began his career in the oil business.

T. J. McMAHON

He was with the Producers and Refiners Oil Company, the National Transit Oil Company, and the Southwest Pennsylvania Pipe Line Company before he went to Houston in April, 1908, to join The Texas Company.

He was first an oil dispatcher for The Texas Company, later becoming chief dispatcher. He was transferred to The Texas Pipe Line Company when it was organized in 1917, and was made a vice-president of the company in October, 1928. He had been a director of the Texas-New Mexico Pipe Line Company since it was organized in 1937.

In 1928, McMahon was chiefly responsible for effecting a permanent organization of telegraph, telephone, and electrical superintendents of oil companies into the Petroleum Industry Electrical Association. At its first and organizational meeting in Fort Worth, Texas, March 21, 1928, he was elected president and chairman of the board of directors of the P.I.E.A., after serving as temporary chairman of the convention. He was re-elected president in 1929 and continued to serve as chairman of the board of directors until April, 1934.

J. S. Warren Elected President Maloney Tank Company

The Maloney Tank Manufacturing Company, Tulsa, Oklahoma, has announced the election of J. S. Warren as president, succeeding the late Harry Ross, who died at Long Beach, California, on April 9. Other officers elected were George J. Maloney, Long Beach, vice-president, and J. C. Highfill, Tulsa, secretary.

J. S. WARREN

Warren, who is a native of Kentucky, has been an executive of the Maloney Tank Manufacturing Company since 1914. He advances to the position of president from that of vice-president and treasurer. He will also continue as general manager of the company, a position held for many years.

MEETINGS

13th International Congress of Carbide, Acetylene, Oxy-Acetylene Welding and Allied Industries—June 25, 26, 27, 28, 29, 30, and July 1, Munich, Germany.

American Society for Testing Materials, Annual Meeting—June 26, 27, 28, 29, and 30, Chalfonte-Haddon Hall, Atlantic City, New Jersey.

California Natural Gasoline Association—July 6, Richfield Building, Los Angeles, California.

American Institute of Mining and Metallurgical Engineers, Regional Meeting—July 10, 11, 12, 13, 14, 15, 16, and 17, San Francisco, California.

Eastern U. S. Michigan Oil and Gas Exposition——August 1, 2, 3, 4, 5, and 6, Mt. Pleasant, Michigan.

Appalachian Gas Measurement Short Course—August 21, 22, and 23, Morgantown, West Virginia.

American Society of Mechanical Engineers—September 4, 5, 6, 7, and 8, New York, New York.

American Chemical Society—September 9, 10, 11, 12, and 13, Detroit, Michigan.

American Institute of Mining and Metallurgical Engineers, Petroleum Division—October 4, 5, and 6, Galveston, Texas.

American Gas Association, Annual Convention—October 9 and 10, New York, New York.

National Safety Congress and Exposition—October 16, 17, 18, 19, and 20, Chalfonte-Haddon Hall, Atlantic City, New Jersey.

Independent Petroleum Association of America, Tenth Annual Meeting—October 18, 19, and 20, Fort Worth, Texas.

American Institute of Mining and Metallurgical Engineers, Petroleum Division—October 19 and 20, Los Angeles, California.

American Petroleum Institute, 20th Annual Meeting—November 13, 14, 15, 16, and 17, Stevens Hotel, Chicago, Illinois.

American Institute of Chemical Engineers—November 15, 16, and 17, Providence, Rhode Island.

American Society of Mechanical Engineers—December 4, 5, 6, and 7, Philadelphia, Pennsylvania.

International Petroleum Exposition—May 18, 19, 20, 21, 22, 23, 24, and 25, 1940, Tulsa, Oklahoma.

Third World Petroleum Congress—June 9, 10, 11, 12, 13, 14, and 15, 1940, Berlin, Germany.

Goodson Rieger with Texasteel

The Texasteel Manufacturing Company, Fort Worth, Texas, announces the appointment of Goodson Rieger as sales manager for its southwest Texas and the Gulf Coast areas. Rieger became connected with the oil industry in 1918 in the boom days of Desdemona, Texas, and until a year ago had spent nine years as deputy supervisor of the Texas Railroad Commission in charge of the Houston district. Since leaving the Commission and until recently he has been with the Emsco Screen Pipe Company in Houston.

Rieger will continue to make his home at 2913 Cason Street in Houston and will specialize in the distribution of surface pumping equipment and electric-steel sucker rods and pull rods.

Gotkool
WATER CANS & COOLERS

GOTT WATER CAN
Made in 1½, 3, 5, and 10 gallon sizes.

GOTT Water Cans are the practical way to keep drinking water cool for long periods, protected from impurities and always handy to the job. Snug fitting large removable top, strongly built to withstand rough usage. GOTT Water Coolers have extra large covers and a handy non-leaking push button faucet. Your Supply Store has them, get one today! . . . . .

GOTT WATER COOLER
Made in 3, 5, 8, 10 and 20 gallon sizes

H. P. GOTT MFG. CO.
WINFIELD, KANSAS

KEEP PURE DRINKING WATER ALWAYS HANDY

YOU ARE THE ONLY JUDGE!

"The Entirely Different Boiler and Engine Treatment"

You don't have to take our word, or the word of hundreds of satisfied users, that Sand-Banum safely eliminates all scale and corrosion from boilers and engines. You simply:

PROVE ITS MERIT IN YOUR OWN EQUIPMENT! Arrange to test this pure colloidal concentrate for 30, 60 or 90 days. If is doesn't do a more efficient and more economical job — *you pay us nothing!*

Remember, it is also the simplest method available. It comes in 16-oz. cans — ready to use. One can protects a 250 Hp. boiler for a month regardless of the operating conditions or the nature of the water used. OK a test today and know "The Best Way"!

AMERICAN SAND-BANUM COMPANY, Inc.
9 Rockefeller Plaza New York City

Look for the *Arm-and-Hammer*
ARMSTRONG BROS.
Adjustable
DIES
and . . .
STOCKS

Alloy Steel Chasers with Backed Off Teeth

Cut faster, easier; cut *smooth threads.* Dies are Chrome-Vanadium Steel, have backed-off teeth, correct Cutting Angle, correct Throat Angle and Ample Chip Clearance.
Free from ridges and corners. Stocks fit comfortably in hand, are balanced, are accurately machined inside. Take all dies.
Write for Catalog of Better Pipe Tools.

ARMSTRONG BROS. TOOL CO.
"The Tool Holder People"
331 N. Francisco Ave., CHICAGO, U. S. A.

KEEP YOUR FILE
COMPLETE ON

THE PETROLEUM ENGINEER'S "CONTINUOUS TABLES"

Renew Your Subscription Promptly Upon Expiration!

If You're Having Trouble with **THREADED** or **GASKET** Connections

Write for This Booklet!

This 16-page pocket manual tells the story of RECTORSEAL, which seals and maintains a leakproof joint, yet permits easy "breakout". It forms a plastic, elastic mass, impervious to oil, gas, acids, salt water, or steam up to 400° F., and is now profitably used on many oil industry applications described and pictured in this booklet. A copy is yours for the asking.

MAIL COUPON BELOW

RECTOR WELL EQUIPMENT CO.,
Fort Worth National Bank Bldg.,
Fort Worth, Texas.

Please send me, without obligation, your Rectorseal Booklet.

Name .....

Company .....

Address .....

RECTORSEAL
THE POSITIVE LEAK PREVENTER

INDEX *to* ADVERTISERS

Abercrombie, J. S., Co.
Abercrombie Pump Company 170
Ajax Iron Works
American Cable Division of American Chain & Cable Co., Inc. Inside Back Cover
American Chain & Cable Company, Inc. Inside Back Cover
American Hammered Piston Ring Division 83-84
American Iron and Machine Works Co. Back Cover
American Meter Co. 10
American Pipe & Steel Corporation
American Roller Bearing Company 6
American Rolling Mill Co. 161
American Sand-Banum Co., Inc 179
American Steel & Wire Co. 77
Arkansas Power & Light Co. 130
Armstrong Bros. Tool Co. 179
Axelson Manufacturing Co. 163

Baash-Ross Tool Co. 4
Baker Oil Tools, Inc. 157
Baroid Sales Co. 145
Bartlett-Hayward Division 83-84
Benjamin Electric Mfg. Co. 137
Bethlehem Steel Co. 60
Bradford Motor Works, Inc. 177
Brewster Company, Inc.
Bridgeport Machine Company
Broderick & Bascom Rope Co.
Buckeye Traction Ditcher Co.
Byron Jackson Co. 1 and 8

Cameron Iron Works 158
Central Power and Light Co. 105
Chaplin-Fulton Mfg. Co., The 176
Chapman Valve Mfg. Co., The 64
Clark Bros. Co. 80-81
Climax Molybdenum Co.
Continental Supply Co., The 143
Cook, C. Lee, Mfg. Co. 23
Cooper-Bessemer Corp., The
Covic Diesel Division of Northill Co.
Crane Co. 58
Cummins Engine Co. 45

Diamond Chain & Mfg. Co. 2
Dowell, Incorporated 19

Eastman Oil Well Survey Co.
Elliott Core Drilling Co. 8
Ensign Carburetor Co., Ltd.

Fluid Packed Pump Co. 21
Frick-Reid Supply Corporation
Gaso Pump & Burner Mfg. Co.
General Electric Co. 115
General Power, Inc. 71
Gilmore Wire Rope Division, Jones & Laughlin Steel Corp.
Gott, H. P., Mfg. Co. 179
Gray Tool Co.
Guiberson Corporation
Gulf States Utilities Company 127

Halliburton Oil Well Cementing Company Front Cover
Harrisburg Steel Corporation 66
Hazard Wire Rope Division of American Chain & Cable Co., Inc.
Houston Lighting & Power Co. 93
Hughes Tool Company 154-155
Hyatt Bearings Division, General Motors Corp. 62

Illinois Iowa Power Co. 137
Illinois Northern Utilities Co. 137
International Derrick & Equipment Co.
International Geophysics, Inc.
International Harvester Company 41
International Petroleum Exposition
Jarecki Mfg. Co.
Jeffrey Mfg. Co.
Jensen Bros. Mfg. Co. 173
Jerguson Gage & Valve Co. 168
Jones & Laughlin Steel Corporation, Gilmore Wire Rope Division

Kansas City Power and Light Co. 113
Kansas Gas & Electric Co. 94
Koppers Company 83-84
American Hammered Piston Ring Division, Bartlett Hayward Division, Engineering and Construction Division, Western Gas Division, Wood Preserving Corp., The

Lane-Wells Co. 79
Larkin Packer Co., Inc. 56
Layne & Bowler Co.
Leschen, A. & Sons Rope Co. 13
Lincoln Electric Co.
Link-Belt Company 173
Lone Star Cement Corp. 43
Lufkin Foundry & Machine Co. 38-39
Lunkenheimer Co., The 69

McKissick Products Corp.
MacClatchie Mfg. Co.
Macwhyte Company 3
Marley Co. 171
Martin Decker Corp 169
Mathey, C. A., Machine Works 174
Merco Nordstrom Valve Co.
Metric Metal Works 10
Mission Mfg. Co. 151

National Supply Companies, The 152
National Tube Co. 75

Oakite Products, Inc. 175
O'Bannon, Walter, Co. 174
Oil Center Tool Co. 16
Oil Well Supply Co. 73
Oklahoma Gas & Electric Co. 102-103
Otis Pressure Control, Inc.

Panhandle Power & Light Co. 113
Parkersburg Rig & Reel Co.
Patterson-Ballagh Corporation 176
Penberthy Injector Co. 15
Petroleum Electric Power Club 110, 111, and 140
Petroleum Rectifying Co.
Pittsburgh Equitable Meter Co.
Public Service Company of Northern Illinois 107
Public Service Co. of Oklahoma 99

Rector Well Equipment Co. 180
Reda Pump Company 88
Reed Roller Bit Company 24
Regan Forge & Engineering Co. 9
Republic Steel Corp. 46-47
Ridge Tool Co. 175

Schlumberger Well Surveying Co.
Security Engineering Co. 147
Shaffer Tool Works
Smith, A. O., Corp. 148-149
Smith, E. M., Company 167
South Chester Tube Co.
Southwestern Gas & Electric Co. 96-97
Spang Chalfant, Inc. 5
Spang & Company
Sperry-Sun Well Surveying Co.
Texas Electric Service Company 117
Texas Iron Works
Texas Power & Light Company 123
Texas State Hotel 178
Thermoid Co.
Tretolite Company Inside Front Cover
Trinity Portland Cement Co.
Tulsa Hotel 178

Union Wire Rope Corporation 165
U. S. Steel Corporation Subsidiaries 73, 75, and 77

Westinghouse Electric & Mfg. Co. 120
West Texas Utilities Company 119
Wilson Supply Co.
Wyatt Metal & Boiler Works
Young Engine Corp.
Youngstown Sheet & Tube Co. 7

Zink, John, Co.